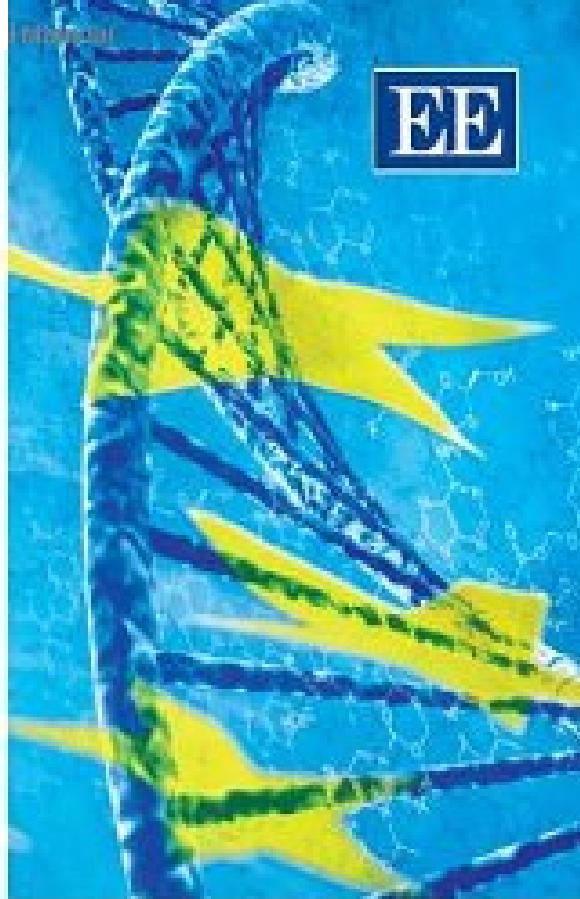


Edited by
Elias G. Carayannis
George M. Korres



The Innovation Union in Europe

A Socio-Economic Perspective
on EU Integration

The Innovation Union in Europe

SCIENCE, INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Series editors: Elias G. Carayannis, *Professor of Science, Technology, Innovation and Entrepreneurship, School of Business, George Washington University, USA* and Aris Kaloudis, *NIFU STEP Studies in Innovation, Research and Education, Oslo, Norway*

There is ample and growing evidence that intangible resources such as knowledge, know-how and social capital will prove to be the coal, oil, and diamonds of the twenty-first century for developed, developing, and emerging economies alike. Moreover, there are strong indications and emerging trends that there are qualitative and quantitative differences between the drivers of economic growth in the twentieth and twenty-first centuries.

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ENTREPRENEURSHIP

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Contents

<i>List of contributors</i>	vii
<i>Preface</i>	viii

PART I INNOVATION AND THE KNOWLEDGE-BASED ECONOMY

1 The innovation ecosystem	3
<i>Elias G. Carayannis</i>	
2 Patterns of innovation and the determinants of the diffusion process in selected EU member states	42
<i>George M. Korres</i>	
3 Building the innovation union: lessons from the 2008 financial crisis	58
<i>Alice O. Nakamura, Leonard I. Nakamura and Masao Nakamura</i>	

PART II NATIONAL AND REGIONAL SYSTEMS OF INNOVATION

4 The European national and regional systems of innovation	85
<i>George M. Korres</i>	
5 European innovation policies from RIS to smart specialization: a policy assemblage perspective	99
<i>Arnoud Lagendijk and Krisztina Varró</i>	

PART III THE FUTURE OF INNOVATION AND PROSPECTS FOR SOCIO-ECONOMIC INTEGRATION

6 Innovation diplomacy as driver of democracy, innovation and development: the case of Greece	123
<i>Elias G. Carayannis</i>	

7	Spatial knowledge spillovers within and between European regions: a meta-analysis <i>Urban Gråsjö, Charlie Karlsson and Peter Warda</i>	144
8	Innovation, efficiency and economic integration <i>Aikaterini Kokkinou</i>	176
	<i>Index</i>	191

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Preface

Much of the economic and social progress due to technology, along with the growing importance of technological change in world production and employment, has been characteristic of the last four decades. Technological change not only determines growth but also affects international competition and modernization within an economy. Technology has been central to both economic growth and core elements of social welfare that are only partly captured by standard measures of gross domestic product (GDP), including health, education and gender equality.

Technology creation and diffusion are the main components not only of innovation and growth but also of their long-run sustainability, with adoption and diffusion of new technologies affecting economic structure and competitiveness.

The concept of innovation has been frequently used almost as a synonym for technical change. In this case, innovation is seen as a process that has linkages and feedbacks, and connects all the elements of the Schumpeterian triad: invention, innovation and diffusion, together with the more coherent concept of incremental innovation. Within this framework, development is understood as the process of economic transformation brought about by innovation. This concept of development could, therefore, be considered, to a certain degree, as a background for the systems of innovation approach, because this is a core tool for the study of an economy's ability to create and diffuse innovation, and furthermore to 'develop'. The term 'system of innovation' indicates the national technological capabilities, as well as the structure and planning of research and development, with European innovation systems nowadays playing an important role in the economies of EU member states.

One of the most important economic events of recent decades in Europe has been the process of European economic integration. Economic theory, however, is unclear with respect to the effects of economic integration. This book offers such an empirical analysis. It uses the unique example of the EU to analyse whether convergence or divergence occurred among the involved member states. However, this book asserts that convergence and divergence may occur in various ways, mainly affected by national or regional dynamic conditions.

The book argues that national or regional economic development depends mainly on technical change, social and human capital, and knowledge creation and diffusion. The book is intended to provide a basic understanding of the current issues and the problems of the knowledge economy, technical change and innovation activities; it also examines many aspects and consequences of regional integration that are obscure or yet to be explored. In particular, with its wide range of topics, methodologies and perspectives, the book offers stimulating and wide-ranging analyses that will be of interest to students, economic theorists, empirical and social scientists and policy makers, as well as the informed general reader.

The book consists of eight chapters, as follows:

- Chapter 1 focuses on the nature and dynamics of research, education and innovation from a public as well as a private perspective (fractal research, education and innovation ecosystem – FREIE) in the context of the quadruple innovation helix and the Mode 3 knowledge production system architecture.
- Chapter 2 attempts to examine the main models and to review the patterns and the determinants of the diffusion process, and also to analyse the role and the impact of the relationship between adoption, innovation activities, diffusion process and development process.
- Chapter 3 focuses on the innovation initiatives of the EU. It is essential to extend the scope of the initiative to include innovation for financial sector products, processes and regulatory approaches. The authors make this argument using examples of financial sector innovations in the USA following the Great Depression and on the basis of an examination of the 2008 financial crisis.
- Chapter 4 attempts to examine the structure and role of national and regional systems of innovation and their implications for sustainable development and integration and convergence in the EU.
- Chapter 5 attempts, using a theoretical framework, to review the distinction between coding and territorialization. Moreover, a historical account of policy evolution is presented using key documents and evaluations published by EU departments and (funded) organizations dealing with regional innovation policy.
- Chapter 6 focuses on the nature and dynamics of entrepreneurship and innovation as drivers of economic development and their interdependencies and interaction with political regimes in which they exist, with reference to Greece.
- Chapter 7 focuses on one type of externality, namely knowledge spillovers. The empirical studies of the effects of knowledge

spillovers in Europe have normally focused on the localized effects on either total factor productivity or knowledge production measured in terms of patent output. The purpose of this chapter is to quantitatively review the empirical literature on spatial knowledge spillovers within and between European regions by means of meta-analysis to determine the extent to which such spillovers have been empirically documented as well as their spatial reach. In addition, the authors have applied a meta-regression analysis to analyse the determinants of observed heterogeneity across and between publications.

- Chapter 8 attempts to examine the economic role of innovation and efficiency enhancement in economic integration and convergence that is even more important, taking into consideration the slow-down and the effects created by the current financial crisis. Within this framework, the key factors influencing the integration and convergence process are creation and diffusion of innovation, along with productive efficiency enhancement, mainly around three key areas: innovation and research; strengthening networks and clusters; and efficient use of production factors.

We would like to thank the contributors to this volume and also the anonymous reviewer, and, above all, our publisher for encouragement and support.

Elias G. Carayannis
George M. Korres

PART I

Innovation and the Knowledge-Based Economy

1. The innovation ecosystem

Elias G. Carayannis

1. INTRODUCTION

1.1 Specialized Knowledge as Key to Competitive Advantage

Developed and developing economies alike face increased resource scarcity and competitive rivalry. Science and technology increasingly appear as a main source of competitive and sustainable advantage for nations and regions alike. However, the key determinant of their efficacy is the quality and quantity of entrepreneurship-enabled innovation that unlocks and captures the pecuniary benefits of the science enterprise in the form of private, public or hybrid goods. In this context, linking university basic and applied research with the market, via technology transfer and commercialization mechanisms including government–university–industry partnerships and risk capital investments, constitutes the essential trigger mechanism and driving device for sustainable competitive advantage and prosperity. In short, university researchers, properly informed, empowered and supported, are bound to emerge as the architects of a prosperity that rests on a solid foundation of scientific and technological knowledge, experience and expertise, and not in fleeting and conjectural ‘financial engineering’ schemes. Building on these constituent elements of technology transfer and commercialization, ‘open innovation diplomacy’ encompasses the concept and practice of bridging distance and other divides (cultural, socio-economic, technological etc.) with focused and properly targeted initiatives to connect ideas and solutions with markets and investors ready to appreciate them and nurture them to their full potential. Chapter 6 develops this in more detail.

The emerging gloCalizing (global/local; Carayannis and von Zedtwitz, 2005; Carayannis and Alexander, 2006) frontier of converging systems, networks and sectors of innovation that is driven by increasingly complex, non-linear and dynamic processes of knowledge creation, diffusion and use confronts us with the need to reconceptualize – if not reinvent – the

ways and means that knowledge production, utilization and renewal take place in the context of the knowledge economy and society.

Perspectives from and about different parts of the world and diverse human, socio-economic, technological and cultural contexts are interwoven to produce an emerging new worldview on how specialized knowledge, embedded in a particular socio-technical context, can serve as the unit of reference for stocks and flows of a hybrid, public/private, tacit/codified, tangible/virtual good that represents the building block of the knowledge economy, society and polity.

Thus the major purposes of this chapter could be paraphrased as:

- (a) adding to the theories and concepts of knowledge further discursive inputs, such as suggesting a linkage of systems theory and the understanding of knowledge, emphasizing multi-level systems of knowledge and innovation, summarized as the Mode 3 knowledge production systems approach to knowledge creation, diffusion and use that we discuss below;
- (b) using this diversified and conceptually pluralized understanding to support practical and application-oriented decision making with regard to knowledge, knowledge optimization and the leveraging of knowledge for other purposes, such as economic performance: knowledge-based decision making has ramifications for knowledge management of firms (global multinational corporations) and universities as well as for public policy (knowledge policy, innovation policy);
- (c) exploring, identifying and understanding the key triggers, drivers, catalysts and accelerators of high-quality and -quantity (continuous as well as discontinuous, reinforcing as well as disruptive) innovation and sustainable entrepreneurship (financially and environmentally – see Carayannis and Campbell, 2010) that serve as the foundations of robust competitiveness within the operational framework of open innovation diplomacy (Carayannis and Campbell, 2011) and diaspora entrepreneurship and innovation networks (*ibid.*) (see also Chapter 6).

1.2 Mode 3 Knowledge Production System

We postulate that one approach to the required reconceptualization is what I call the ‘Mode 3’ knowledge production system (expanding and extending the ‘Mode 1’ and ‘Mode 2’ knowledge production systems), which is at the heart of the fractal research, education and innovation ecosystem (FREIE¹) (‘innovation ecosystem’ for short²) consisting of

‘innovation networks’ and ‘knowledge clusters’ (see definitions below) for knowledge creation, diffusion and use (Carayannis and Campbell, 2006a).

‘Mode 3’ is a multi-lateral, multi-nodal, multi-modal, and multi-level systems approach to the conceptualization, design, and management of real and virtual, ‘knowledge-stock’ and ‘knowledge-flow’, modalities that catalyze, accelerate, and support the creation, diffusion, sharing, absorption, and use of co-specialized knowledge assets. ‘Mode 3’ is based on a system-theoretic perspective of socio-economic, political, technological, and cultural trends and conditions that shape the co-evolution of knowledge with the ‘knowledge-based and knowledge-driven, gloCal economy and society’. (Carayannis and von Zedtwitz, 2005, p. 22).

The Mode 3 knowledge production system is in short the nexus or hub of the emerging twenty-first-century innovation ecosystem, where people,³ culture⁴ and technology⁵ (Carayannis and Gonzalez, 2003) meet and interact to catalyze creativity, trigger invention and accelerate innovation across scientific and technological disciplines, public and private sectors (government, university, industry and non-governmental knowledge production, utilization and renewal entities, as well as other civil society entities, institutions and stakeholders) in a top-down, policy-driven as well as bottom-up, entrepreneurship-empowered fashion. One of the basic ideas of this chapter is the coexistence, co-evolution and co-specialization of different knowledge paradigms and different knowledge modes of knowledge production and knowledge use. We can postulate a dominance of knowledge heterogeneity at the systems (national, transnational) level. Only at the subsystem (sub-national) level should we expect homogeneity. We can paraphrase this understanding by the term ‘Mode 3’ knowledge production system.

1.3 Mode 3 and Systems Theory

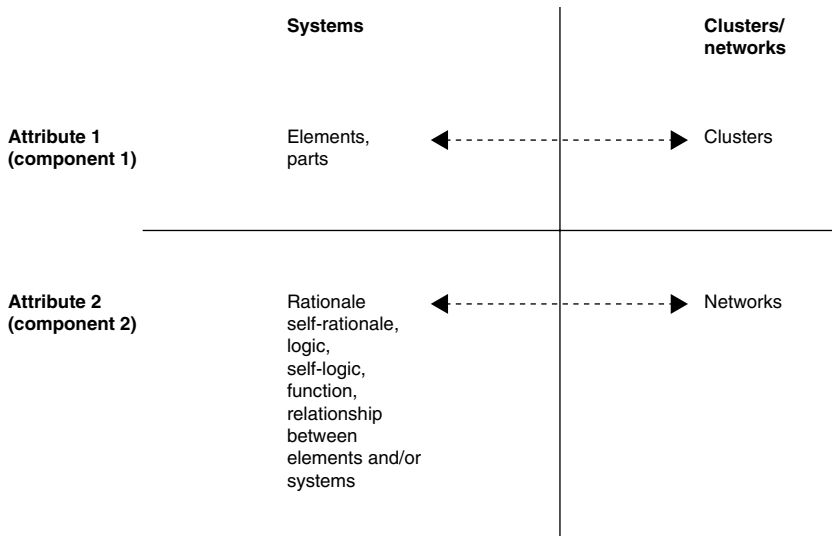
Embedding concepts of knowledge creation, diffusion and use in the context of general systems theory could prove mutually beneficial and enriching for systems theory as well as knowledge-related fields of study, as this could:

- (a) reveal for systems theory a new and important field of application; and
- (b) at the same time, provide a better conceptual framework for understanding knowledge-based and knowledge-driven events and processes in the economy, and hence reveal opportunities for optimizing public sector policies and private sector practices.

To fully leverage the potential of systems (and systems theory) one should demonstrate how a system design can be brought in line with other available concepts, such as innovation networks and knowledge clusters. With regard to clusters, at least three types can be listed:

1. *Geographic (spatial) clusters* Here a cluster represents a certain geographic, spatial configuration, either tied to a location or to a larger region. Geographic, spatial proximity, for example for the exchange of tacit knowledge, is considered crucial. While 'local' clearly represents a sub-national entity, a 'region' could be either sub-national or transnational.
2. *Sectoral clusters* Here different industrial or business sectors develop specific profiles with regard to knowledge production, diffusion and use. One could add that sectoral clusters even support the advancement of particular 'knowledge cultures'. In innovation research, the term 'innovation culture' is now acknowledged (Kuhlmann, 2001, p. 958).
3. *Knowledge clusters* Knowledge clusters are agglomerations of co-specialized, mutually complementary and reinforcing knowledge assets in the form of 'knowledge stocks' and 'knowledge flows' that exhibit self-organizing, learning-driven, dynamically adaptive competences and trends in the context of an open systems perspective. Here, a cluster represents a specific configuration of knowledge, and possibly also of knowledge types. However, in geographic (spatial) and sectoral terms, a knowledge cluster is not predetermined. In fact, a knowledge cluster can cross-cut different geographic locations and sectors, thus operating globally and locally (across a whole multi-level spectrum). It may express an innovative capability, and produce knowledge that excels (knowledge-based) economic performance. A knowledge cluster, furthermore, may include more than one geographic and/or sectoral clusters.

Networks emphasize interaction, connectivity and mutual complementarity, and reinforcement. They can be regarded as the internal configuration that ties together and determines a cluster, and can also express the relationship between different clusters. The concept of networking is important for understanding the dynamics of advanced and knowledge-based societies. Networking links together different modes of knowledge production and knowledge use, and also connects (sub-nationally, nationally, transnationally) different sectors or systems of society. Systems theory, as presented here, is flexible enough for integrating and reconciling systems and networks, thus creating conceptual synergies. Innovation



Source: Carayannis and Campbell (2009).

Figure 1.1 Theoretical equivalents between conceptual attributes of systems and clusters/networks

networks are real and virtual infrastructures and infra-technologies that serve to nurture creativity, trigger invention and catalyze innovation in a public and/or private domain context (e.g. government–university–industry public–private research and technology development co-opetitive partnerships) (see Carayannis and Alexander, 1999a, 2004). Innovation networks and knowledge clusters thus resemble a matrix, indicating the interactive complexity of knowledge and innovation. Should the (proposed) conceptual flexibility of systems (and systems theory) be fully leveraged, it appears important to demonstrate how systems relate conceptually to knowledge clusters and innovation networks, as they are key in understanding the nature and dynamics of knowledge stocks and flows. We suggest linking the two basic components (attributes) of systems ('elements/parts' and 'rationale/self-rationale'; Campbell, 2001, p. 426) with clusters and networks (Carayannis and Campbell, 2006a, pp. 9–10). What results is a formation of two pairs of theoretical equivalents (see Figure 1.1).

1. *Elements and clusters* The elements (parts) of a system can be regarded as an equivalent to clusters (knowledge clusters).

2. *Rationale and networks* The rationale (self-rationale) of a system can be understood as equivalent to networks (innovation networks).

The rationale of a system holds together the system elements and expresses the relationship between different systems. It could be argued that, at least partially, this rationale manifests itself ('moves through') networks. At the same time, elements of a system might also manifest themselves as clusters. Perhaps networks could be affiliated with the functions of a system, and clusters with the structures of systems. This would help to show us what to look for. This, obviously, does not imply that structures and functions of knowledge (innovation) systems fall only into the conceptual boxes of 'clusters' and 'networks'. However, clusters and networks should be regarded as crucial subsets for the elements and rationales of systems.

This equation (between elements/clusters and rationales/networks) might need further conceptual and theoretical development. But it opens a convincing route for better understanding knowledge and innovation, through tying together two strong conceptual traditions (systems theory with clusters and knowledge). A further ramification of networks, as we will demonstrate later on, could also imply understanding knowledge strategies as complex network configurations.

1.4 Integrating Different Knowledge Modes

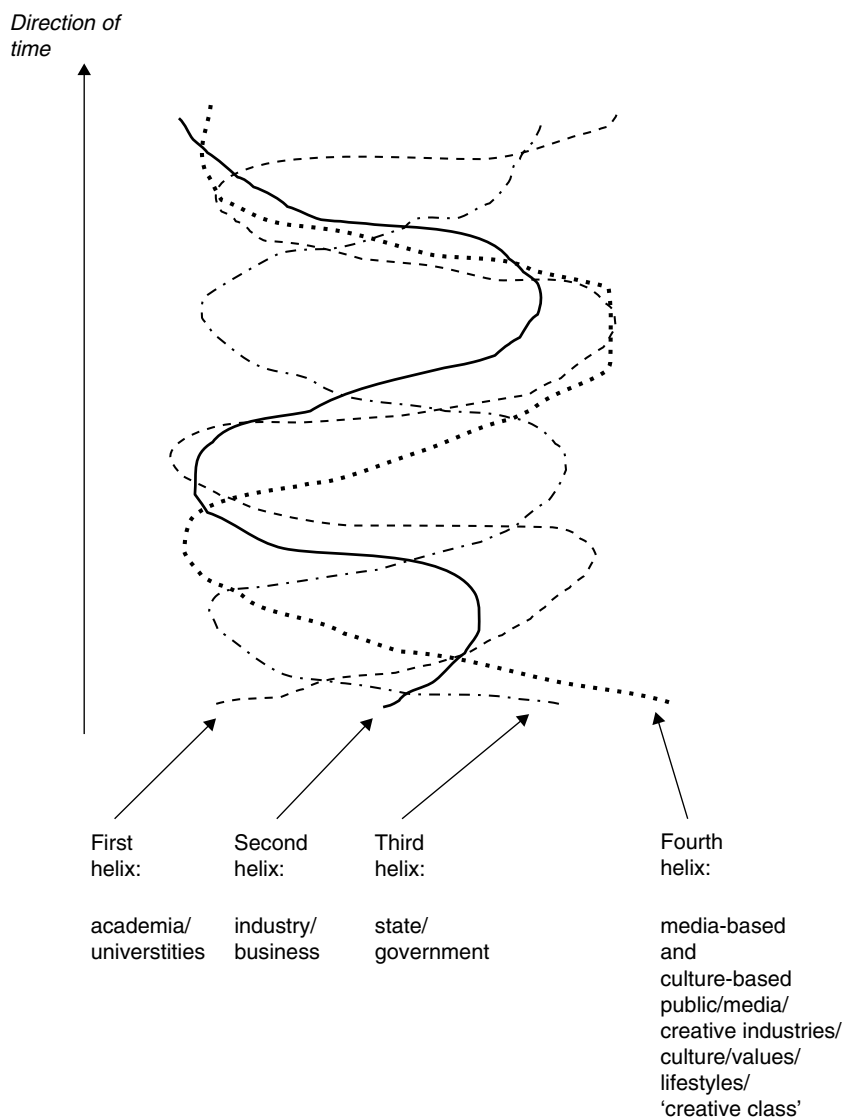
The following presents in greater detail different aspects of advanced knowledge. Crucial for the suggested 'Mode 3' approach is the idea that an advanced knowledge system may integrate different knowledge modes. Some knowledge (innovation) modes will certainly die out. However, what is important for the broader picture is that a co-evolution, co-development and co-specialization of different knowledge modes emerges. This pluralism of knowledge modes should be regarded as essential for advanced knowledge-based societies and economies. This may point to similar features of advanced knowledge and advanced democracy. We could state that the competitiveness and sustainability of the gloCal knowledge economy and society increasingly depend on the elasticity and flexibility of promoting a co-evolution and thereby a cross-integration of different knowledge (innovation) modes. This heterogeneity of knowledge modes should create hybrid synergies.

The 'triple helix' model of knowledge, developed by Henry Etzkowitz and Loet Leydesdorff (2000, pp.111–12), stresses three 'helices' that intertwine and thereby generate a national innovation system: academia/universities, industry, and state/government. Etzkowitz and Leydesdorff

are inclined to speak of ‘university–industry–government relations’ and networks, also placing a particular emphasis on ‘tri-lateral networks and hybrid organizations’, where those helices overlap. In extension of the triple helix model we suggest a ‘quadruple helix’ model (see Figure 1.2), which adds to the above-stated helices a ‘fourth helix’ that we identify as the ‘media-based and culture-based public’. This fourth helix is associated with ‘media’, ‘creative industries’, ‘culture’, ‘values’, ‘lifestyles’, and perhaps also the notion of the ‘creative class’ (a term coined by Richard Florida, 2004). The explanatory potential of such a fourth helix is that culture and values, on the one hand, and the way that ‘public reality’ is being constructed and communicated by the media, on the other hand, influence every national innovation system. The proper ‘innovation culture’ is key to promoting an advanced knowledge-based economy. Public discourses, transported through and interpreted by the media, are crucial for a society to assign top priority to innovation and knowledge (research, technology, education).

Figure 1.3 displays from which conceptual perspectives the co-evolution and cross-integration of different knowledge modes could be approached. Mode 3 emphasizes the additionality and surplus effect of a co-evolution of a pluralism of knowledge and innovation modes. The quadruple helix refers to structures and processes of the gloCal knowledge economy and society. Furthermore, innovation ecosystem stresses the importance of a pluralism of a diversity of agents, actors and organizations: universities, small and medium-sized enterprises and major corporations, arranged along the matrix of fluid and heterogeneous innovation networks and knowledge clusters. All this may result in a ‘democracy of knowledge’, driven by a pluralism of knowledge and innovation and by a pluralism of paradigms for knowledge modes.

In the *Frascati Manual*, the OECD (1994, p. 29) distinguishes between the following categories of research (R&D, research and experimental development): basic research; applied research; and experimental development. Basic research represents a primary competence of university research, whereas business R&D focuses heavily on experimental development. In an empirical assessment of the USA, one of the leading national innovation systems with regard to the financial volume of R&D resources, experimental development ranks first, applied research second and basic research third (see Figure 1.4). What is interesting, however, is the dynamic momentum when observed for a longer period of time. Basic research in the USA grew faster than applied research. In 1981, 13.4 percent of US R&D was devoted to basic research. By 2004, basic research increased its percentage share to 18.7 percent. During the same time period the percentage shares of applied research and experimental development declined

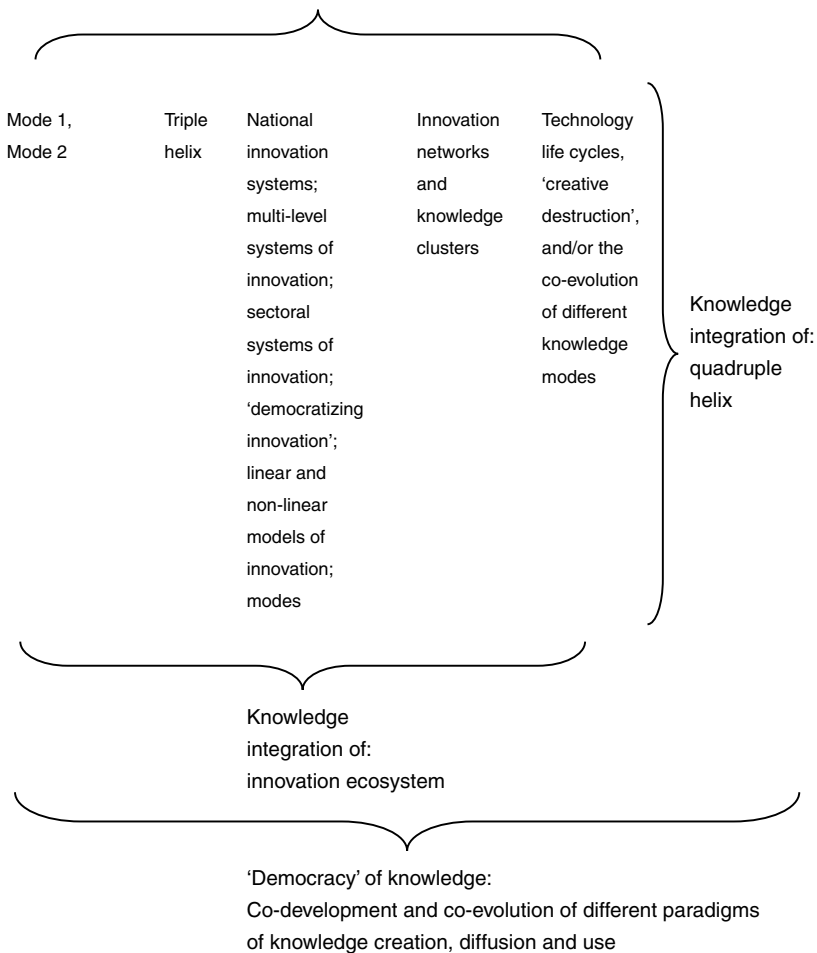


Note: Triple helix: university–industry–government relations (helices); quadruple helix: university–industry–government–media- and culture-based public relations (helices).

Source: Carayannis and Campbell (2009).

Figure 1.2 Conceptualization of the quadruple helix

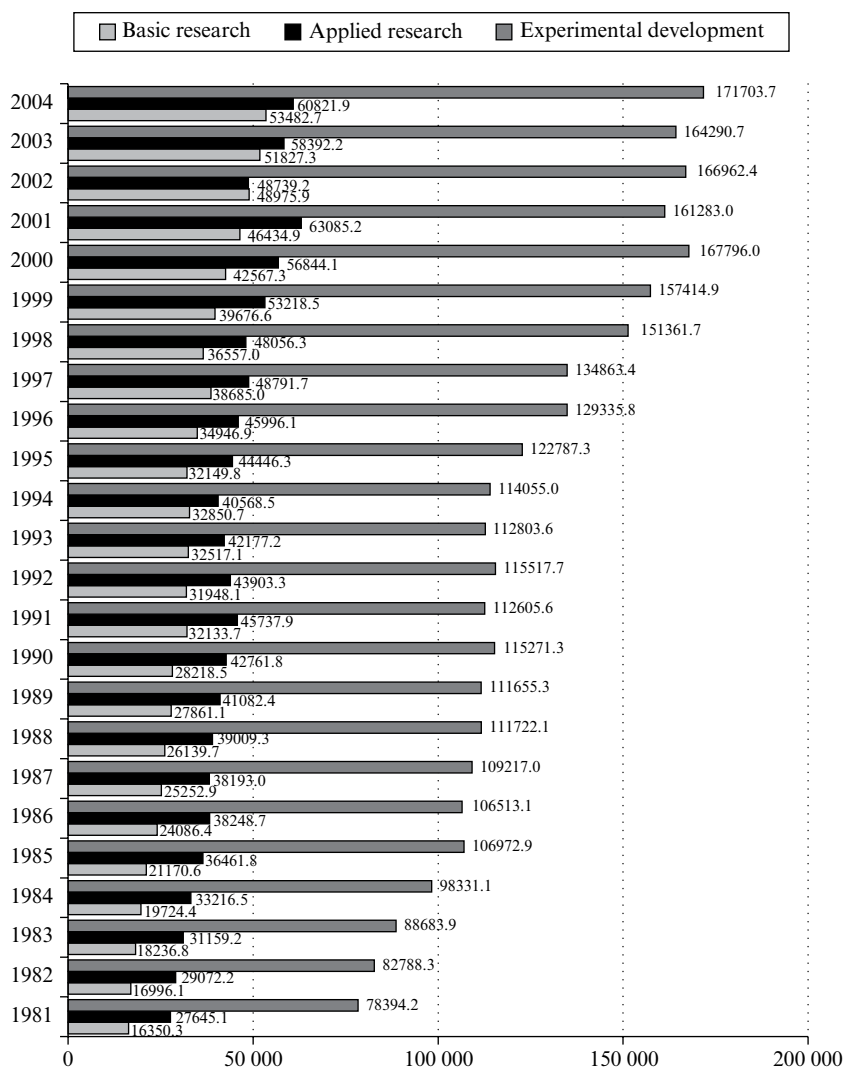
Knowledge integration of Mode 3 knowledge production system:
the core of FREIE



Source: Carayannis and Campbell (2009).

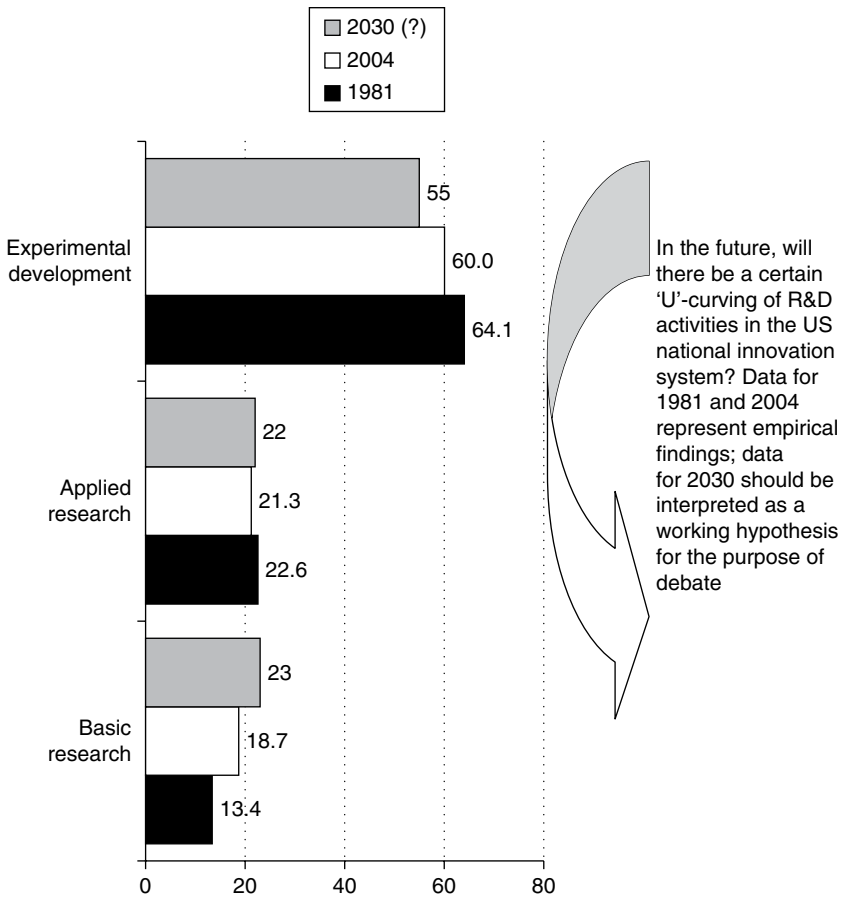
Figure 1.3 Knowledge creation, diffusion and use in a gloCal knowledge economy and society

(Figure 1.5). This links to the question whether we should expect R&D to follow a U-shaped curve for the US innovation system, implying that basic research will further increase its percentage share of overall R&D expenditure. This would go hand in hand with an important gain in basic research.



Source: OECD (2006).

Figure 1.4 National R&D performance of the USA according to the 'R&D activities' of basic research, applied research and experimental development (million constant \$ 2000 prices and PPPs, 1981–2004)



Source: Carayannis and Campbell (2009), based on OECD (2006).

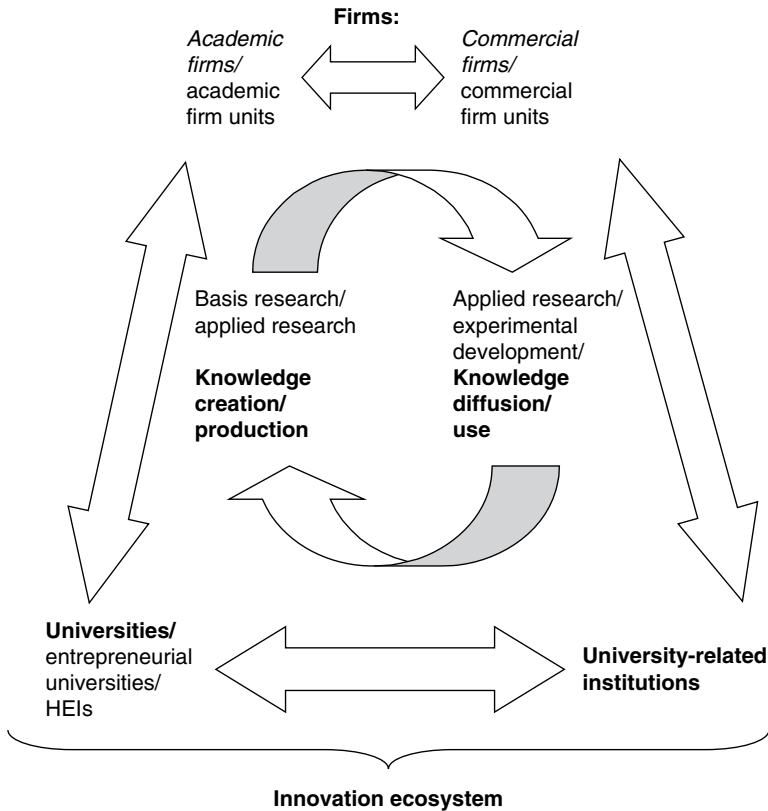
Figure 1.5 National R&D performance of the USA according to the 'R&D activities' of basic research, applied research and experimental development (% of annual R&D activities: 1981, 2004, and a possible projection for 2030)

Furthermore, would such a potential future scenario for the USA also spill over to other national innovation systems?

In a simple interpretation, the linear model of innovation claims that, first, there is basic university research. Later this basic research converts into applied research of intermediary organizations (university-related institutions). Finally, firms pick up, and transform applied research

into experimental development, which is then introduced as commercial market applications. This linear view is often attributed to Vannevar Bush (1945), even though Bush himself, in his famous report, neither mentions 'linear model of innovation' nor even the word 'innovation'. Non-linear models of innovation, on the contrary, underscore a more parallel coupling of basic research, applied research and experimental development. Thus universities or HEIs (higher education institutions), university-related institutions and firms join together in variable networks and platforms for creating innovation networks and knowledge clusters. Even though there continues to be a division of labor and a functional specialization of organizations with regard to the type of R&D activity, universities, university-related institutions and firms can perform, at the same time, basic and applied research and experimental development. Surveys on sectoral innovation in the pharmaceutical sector (McKelvey et al., 2004) and in the chemical sector (Cesaroni et al., 2004) reveal how each of these industries may be characterized by complex network configurations and arrangement of a diversity of academic and firm actors. The innovation ecosystem thus represents a model for a simultaneous coupling of 'non-linear innovation modes' (see Figure 1.6).

The concept of the 'entrepreneurial university' captures the need to link more closely university research with the R&D market activities of firms (see, e.g., Etzkowitz, 2003). Just as important as the entrepreneurial university is the concept of the 'academic firm' (Campbell and Güttel, 2005), which represents the complementary business organization and strategy *vis-à-vis* the entrepreneurial university. The interplay of academic firms and entrepreneurial universities should be regarded as crucial for advanced knowledge-based economies and societies. The following characteristics represent the academic firm (ibid., p.171): 'support of the interfaces between the economy and the universities'; 'support of the paralleling of basic research, applied research and experimental development'; 'incentives for employees to codify knowledge'; 'support of collaborative research and of research networks'; and 'a limited "scientification" of business R&D'. Despite continuing important functional differences between universities and firms, some limited hybrid overlapping may also occur between entrepreneurial universities and academic firms, expressed in the fact that entrepreneurial universities and academic firms can engage more easily in university/business research networks. In an innovation-driven economy, business R&D gains support and excels when it refers to inputs from networking of universities and firms. The academic firm also engages in 'basic business research'. Of course, we must always bear in mind that academic firms and universities are not identical, because academic firms represent commercial units, interested in creating commercial

Model of linear innovation modes:**Model of non-linear innovation modes:**

Source: Carayannis and Campbell (2009).

Figure 1.6 Linear and non-linear innovation modes linking universities with commercial and academic firms

revenues and profits. Alternatively, the academic firm could be seen in two ways: (1) as a concept for the whole firm; (2) or as a concept only for a subdivision, sub-unit or branch of the firm. In many contexts, this second option appears to be more realistic, particularly when we analyze multinational companies or corporations (MNCs) that operate in a global context. For the future, this may have the following implication: how can or should firms balance, within their 'organizational boundary', the principle of the academic and of the traditional 'commercial' firm?

The 'technology life cycles' explain why there is always a dynamic in the gloCal knowledge economy and society (Tassey, 2001). The 'saturation tendency' within every technology life cycle demands the creation and launch of new technology life cycles, leading to the market introduction of next-generation technology-based products and services. In reality, different technology life cycles with a varying degree of market maturity will operate in parallel. To a certain extent, technology life cycles are also responsible for the cyclicity (growth phases) of a modern market economy. Perhaps the most succinct way of describing the economic thinking of Joseph A. Schumpeter is to present the following equation:

$$\text{Entrepreneurship} + \text{leveraging opportunities of new technology life cycles} = \text{Economic growth}$$

Addressing the cyclicity of capitalist economic life, Schumpeter (1942) used the notion of 'creative destruction'. Mode 3 may open up a route for overcoming or transforming the destructiveness of 'creative destruction' (Carayannis et al., 2007).

2. INNOVATION

Innovation is often linked with creating a sustainable market around the introduction of new and superior product or process. Specifically, in the literature on the management of technology, technological innovation is characterized as the introduction of a new technology-based product into the market:

Technological innovation is defined ... as a situationally new development through which people extend their control over the environment. Essentially, technology is a tool of some kind that allows an individual to do something new. A technological innovation is basically information organized in a new way. So technology transfer amounts to the communication of information, usually from one organization to another. (Tornazky and Fleischer, 1990)

The broader interpretation of the term refers to an 'idea, practice or material artifact' (Rogers and Shoemaker, 1971, p 19) adopted by a person or organization, where that artifact is 'perceived to be new by the relevant unit of adoption' (Zaltman et al., 1973). Therefore innovation tends to change perceptions and relationships at the organizational level, but its impact is not limited there. Innovation, in its broader socio-technical, economic and political context, can also substantially impact, shape and evolve ways and means people live their lives, businesses form, compete, succeed and fail, and nations prosper or decline.

From a business perspective, an innovation is perceived as the happy ending of the commercialization journey of an invention, when that journey is indeed successful and leads to the creation of a sustainable and flourishing market niche or new market. Therefore a technical discovery or invention (the creation of something new) is not significant to a company unless that new technology can be utilized to add value to the company, through increased revenues, reduced cost and similar improvements in financial results. This has two important consequences for the analysis of any innovation in the context of a business organization.

First, an innovation must be integrated into the operations and strategy of the organization, so that it has a distinct impact on how the organization creates value or on the type of value the organization provides in the market.

Second, an innovation is a social process, since it is only through the intervention and management of people that an organization can realize the benefits of an innovation.

The discussion of innovation clearly leads to the development of a model to understand its evolving nature. Innovation management is concerned with the activities of the firm undertaken to yield solutions to problems of product, process and administration. Innovation involves uncertainty and disequilibrium. Nelson and Winter (1982) propose that almost any change, even trivial, represents innovation. They also suggest, given the uncertainty, that innovation results in the generation of new technologies and changes in the relative weighting of existing technologies (*ibid.*). This results in the disruptive process of disequilibrium. As an innovation is adopted and diffused, existing technologies may become less useful (reduction in weight factors) or even useless (weighing equivalent to zero) and abandoned altogether. The adoption phase is where uncertainty is introduced. New technologies are not adopted automatically but rather, markets influence the adoption rate (Carayannis and Allbritton, 1997; Rogers et al., 1998). Innovative technologies must propose to solve a market need such as reduced costs or increased utility or increased productivity. The markets, however, are social constructs and subject to non-innovation-related

criteria. For example, an invention may be promising, offering a substantial reduction on the cost of a product which normally would influence the market to accept the given innovation; but due to issues like information asymmetry (the lack of knowledge in the market concerning the invention's properties), the invention may not be readily accepted by the markets. Thus the innovation may remain an invention. If, however, the innovation is accepted by the market, the results will bring about change to the existing technologies being replaced, leading to a change in the relative weighting of the existing technology. This is in effect disequilibrium.

Given the uncertainty and change inherent in the innovation process, management must develop skills and understanding of the process, and a method for managing the disruption. The problems of managing the resulting disruption are strategic in nature. The problems may be classified into three groups: engineering, entrepreneurial, and administrative (Drejer, 2002). This grouping correlates to the related types of innovation, namely, product, process and administrative innovation:

- The engineering problem is one of selecting the appropriate technologies for proper operational performance.
- The entrepreneurial problem refers to defining the product/service domain and target markets.
- Administrative problems are concerned with reducing the uncertainty and risk during the previous phases.

In much of the foregoing discussion of innovation, a recurring theme is that of uncertainty, leading to the conclusion that an effective model of innovation must include a multidimensional approach (uncertainty is defined as unknown unknowns whereas risk is defined as known knowns). One model posited as an aid to understanding is the multidimensional model of innovation (MMI) (Cooper, 1998). This model attempts to define innovation by establishing three-dimensional boundaries. The planes are defined as product–process, incremental–radical, and administrative–technical. The product–process boundary concerns itself with the end product and its relationship to the methods employed by firms to produce and distribute the product. Incremental–radical defines the degree of relative strategic change that accompanies the diffusion of an innovation. This is a measure of the disturbance or disequilibrium in the market. Technological–administrative boundaries refer to the relationship of innovation change to the firm's operational core. The use of 'technological' refers to the influences on basic firm output, while the 'administrative' boundary would include innovations affecting associated factors of policy, resources and social aspects of the firm.

		Knowledge	
		yes	no
Innovation	yes	Knowledge-based innovation or knowledge which, through innovation, is linked with society, economy and politics. Examples: Mode 1 and technology cycles in the long run, Mode 2, triple helix	Innovation, taking place with no (almost no) references to knowledge. Examples: management innovations in businesses, which are not R&D or technology-based
	no	Knowledge, without major references to innovation (and use). Examples: 'pure research', perhaps some components of Mode 1 and of early phases of technology life cycles	? (Not of primary concern for our conceptual mapping)

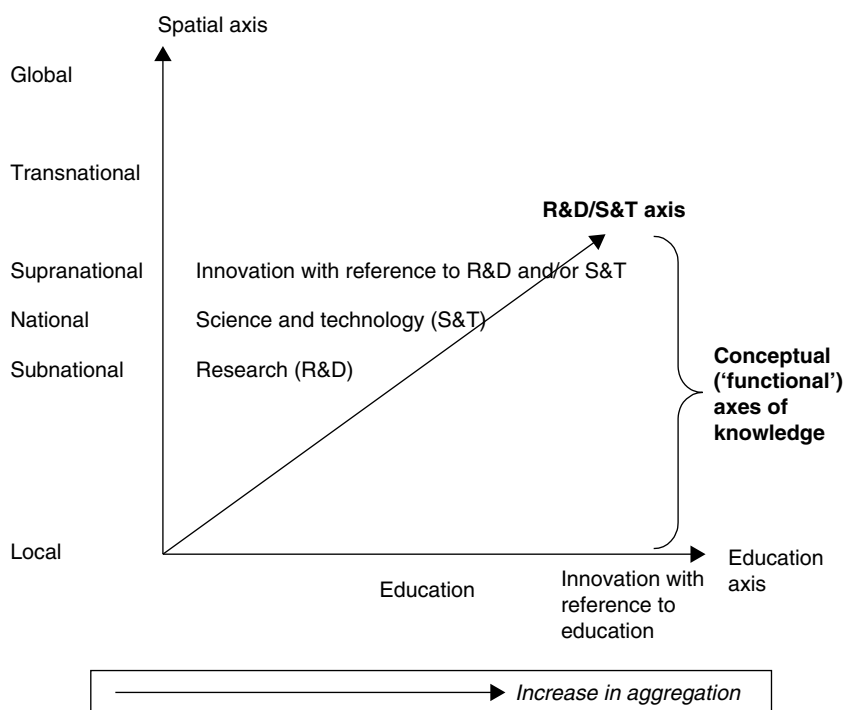
Source: Carayannis and Campbell (2009).

Figure 1.7 A four-fold typology of possible cross-references and interactions between knowledge and innovation

2.1 The Relationship between Knowledge and Innovation

What is the relationship between knowledge and innovation? From our viewpoint it makes sense not to treat knowledge and innovation as interchangeable concepts. The ramifications of this are (see Figure 1.7):

1. There are aspects, areas of knowledge, that can be analyzed without considering innovation (e.g. 'pure basic research' in a linear understanding of innovation).
2. Consequently, there are areas or aspects of innovation that are not (necessarily) tied to knowledge (see various contributions to Shavinina, 2003).
3. However, there are also areas where knowledge and innovation coexist. These we would like to call 'knowledge-based innovation', indicating areas where knowledge and innovation have a mutual interaction.



Source: Carayannis and Campbell (2009).

Figure 1.8 A multi-level modeling knowledge

In the case of knowledge-based innovation, we can then speak of innovation that deals with knowledge. Our impression is that in many contexts, when the focus falls on innovation, almost automatically this type of innovation is implied. Even though we will focus on this knowledge-based innovation, it is important to acknowledge the possibilities of a knowledge without innovation, and of innovation independent of knowledge. To further illustrate our point, the notion of the ‘national innovation system’ or ‘national system of innovation’ (NSI) conventionally expresses linkages to knowledge (see Lundvall, 1992; Nelson, 1993).

In research on the European Union (EU), references to a ‘multi-level architecture’ are quite common (see, e.g., Hooghe and Marks, 2001). This ‘multi-level’ approach is being applied in a diversity of fields, since it supports the understanding of complex processes in a globalizing world. Inspired by this, we suggest using the concept of ‘multi-level systems of knowledge’ (see Figure 1.8; see also Carayannis and Campbell, 2006a).

One obvious axis, therefore, is the spatial (geographic, spatial-political) axis that expresses different levels of spatial aggregations. The national level, coinciding with the nation state (the currently dominant manifestation of arranging and organizing political and societal affairs), represents one type of spatial aggregation. Sub-national aggregations fall below the nation-state level, and point toward local political entities. Transnational aggregations, for example, can refer to the supranational integration process of the EU. This raises the interesting question whether we should be prepared to expect that in the twenty-first century we will also witness a proliferation of supranational (transnational) integration processes in other world regions, possibly implying a new stage in the evolution of politics, where (small and medium-sized) nation-state structures become absorbed by supranational (transnational) clusters (Campbell, 1994). The highest level of transnational aggregation that we currently know is globalization. Interestingly, the aggregation level of the term ‘region(s)’ has never been convincingly standardized. In the context and political language of the EU, regions are understood sub-nationally. American scholars, on the other hand, often refer to regions in a state-transcending interpretation (i.e., a region consists of more than one nation state). The term ‘gloCal’ (explained earlier) underscores the potentials and benefits of a mutual and parallel interconnectedness of different levels.

Despite the importance of this spatial axis, we do not wish to exhaust the concept of multi-level systems of knowledge with spatial-geographic metaphors. We suggest adding on non-spatial axes of aggregation. These we may call conceptual (functional) axes of knowledge. In that context, two axes certainly are pivotal: education and research (R&D, research and experimental development). For research, the level of aggregation can develop accordingly: R&D; S&T (science and technology);⁶ and R&D-based innovation, involving a broad spectrum of considerations and aspects. Obviously, every ‘axis direction’ of further aggregation – as demonstrated here for R&D – depends on a specific conceptual understanding. Should, for example, a different conceptual approach for defining S&T be favored, then the sequence of aggregation might change. (Concerning the education axis, we leave it to the judgment of other scholars what meaningful terms at different levels of aggregation may be.)

How many non-spatial (conceptual) axes of knowledge can there be? We focused on the R&D and education axes, but do not thereby imply that there may not be more than two conceptual axes. Here, at least in principle, a multitude or diversity of conceptual model-building approaches is possible and also appropriate. Perhaps, we could even integrate ‘innovation’ as an additional conceptual axis, following the aggregation line from local, to national and transnational innovation systems.

We would then have to consider what the relationship is between such an 'extra innovation axis' with the 'innovation' of the research and education axes. 'Regional' innovation could cross-refer to local and transnational innovation systems, implying even gloCal innovation systems and processes that simultaneously link through different aggregation levels.

We have already discussed the conceptual boundary problems between knowledge and innovation. One approach to balancing ambiguities in this context is to acknowledge that a partial conceptual overlap exists between a knowledge-centered and an innovation-centered understanding. Depending on the focus of the preferred analytical view, the same 'element(s)' can be conceptualized as part of a knowledge or of an innovation system. Concerning knowledge, we pointed to some of the characteristics of multi-level systems of knowledge, underscoring the understanding of aggregation of spatial and non-spatial (conceptual) axes. Introducing multi-level systems of knowledge also justifies speaking of multi-level systems of innovation, developing the original concept of the national innovation system (Lundvall, 1992; Nelson, 1993) further. For example, the spatial axis of aggregation of knowledge (Figure 1.8) also applies to innovation. Of course, Lundvall (1992, pp. 1, 3) also explicitly stresses that national innovation systems are permanently challenged (and extended) by regional as well as global innovation systems. But, paraphrasing Kuhlmann (2001, pp. 960–61), as long as nation-state-based political systems exist, it makes sense to acknowledge national innovation systems. In a spatial (or geographic) understanding, the term 'multi-level systems of innovation' is already being used (Kaiser and Prange, 2004, pp. 395, 405–6; Kuhlmann, 2001, pp. 970–71, 973). However, only more recently has it been suggested to extend this multi-level aggregation approach of innovation to the non-spatial axes of innovation (Campbell, 2006a; Carayannis and Campbell, 2006a). Therefore multi-level systems of knowledge as well as multi-level systems of innovation are based on spatial and non-spatial axes. A further advantage of this multi-level systems architecture is that it results in a more accurate and realistic description of processes of globalization and gloCalization. For example, internationalization of R&D cross-cuts these different multi-level layers, links together organizational units of business, academic and political actors at national, transnational and sub-national levels (Von Zedtwitz and Heimann, 2006). One interpretation of R&D internationalization emphasizes how different sub-national regions and clusters cooperate on a global scale, creating even larger transnational knowledge clusters.

The concept of 'sectoral systems of innovation' (SSI) cross-cuts the logic of the multi-level systems of innovation or knowledge. A sector is often understood in terms of industrial sectors. Sectors can perform locally/

regionally, nationally and transnationally. Reviews of SSIs often place particular emphasis on: knowledge and technologies; actors and networks; and institutions. Malerba (2004, p. i) recommends that analyses of sectoral systems of innovation should include ‘the factors affecting innovation, the relationship between innovation and industry dynamics, the changing boundaries and the transformation of sectors, and the determinants of the innovation performance of firms and countries in different sectors’.

2.2 Linear versus Non-linear Innovation Models (Modes)

Is the linear model of innovation still valid? In an ideal-typical understanding the linear model states: first there is basic research, carried out in a university context. Later on, this basic research is converted into applied research, and moves from the university to the university-related sectors. Finally, applied research is translated into experimental development, carried out by business (the economy). What results is a first-then relationship, with the universities and/or basic research being responsible for generating the new waves of knowledge creation that are later taken over by business, and where business carries the final responsibility for the commercialization and marketing of R&D. National (multi-level) innovation systems, operating primarily on the premises of this linear innovation model, obviously would be disadvantaged: the time horizon for a whole R&D cycle to reach the markets could be quite extensive (with negative consequences for an economy operating in the context of rapidly intensifying global competition). Furthermore, the linear innovation model exhibits serious weaknesses in communicating user preferences from the market end back to the production of basic research. In addition, how should the tacit knowledge of the users and markets be reconnected to basic research? After 1945, the USA was regarded as a prototype for the linear innovation model system, with a strong university base from where basic research gradually would diffuse to the sectors of a strong private economy, without the intervention of major public innovation policy programs (see Bush, 1945, p. 5). As long as the USA represented the world-leading national economy, this understanding was sufficient. But with the intensification of global competition, the demand for shortening the time horizon from basic research to market implementation of R&D increased (OECD, 1998, pp. 179–81, 185–6). In the 1980s, Japan in particular heavily pressured the USA. In the 2000s, global competition within the triad of the USA, Japan and the EU escalated further, with China and India emerging as new competitors in the global context. In a nutshell, increasing economic competition and intrinsic knowledge demands challenged the linear innovation model.

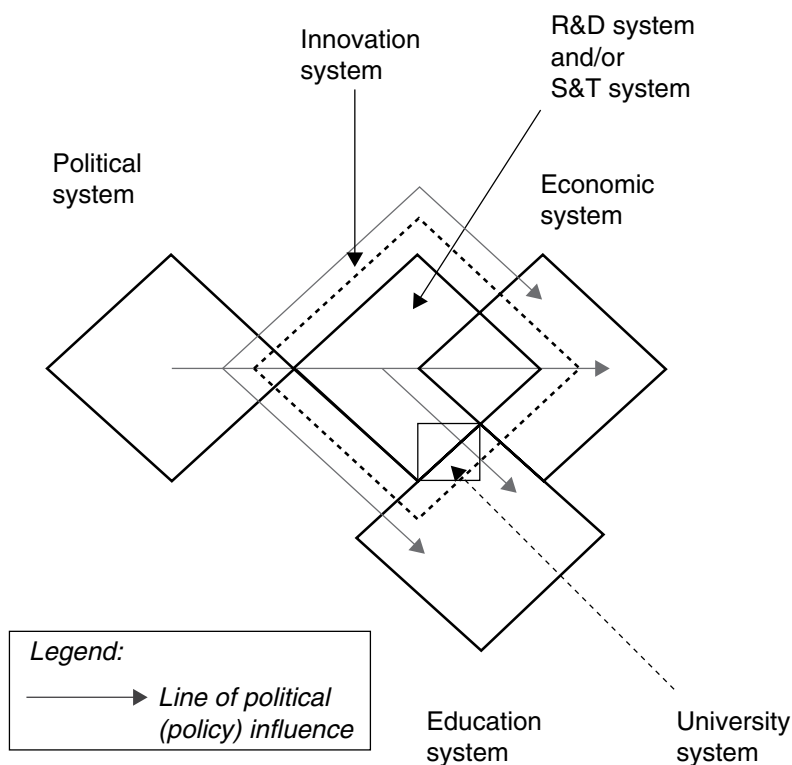
As a consequence, we can observe a significant proliferation of non-linear innovation models. There are several approaches to non-linear innovation models. The ‘chain-linked model’ developed by Kline and Rosenberg (1986; cited in Miyata, 2003, p. 716; see also Carayannis and Alexander, 2006), emphasizes the importance of feedback between the different R&D stages. In particular, the coupling of marketing, sales and distribution with research claims to be important. ‘Mode 2’ (Gibbons et al., 1994, pp. 3–8, 167) underscores the linkage of production and use of knowledge by referring to the following five principles: knowledge produced in the context of application; transdisciplinarity; heterogeneity and organizational diversity; social accountability and reflexivity; and quality control (see also Nowotny et al., 2001, 2003). Metaphorically speaking, the first–then sequence of relationships of different stages within the linear model is replaced by a paralleling of different R&D activities (Campbell, 2000, p. 139–41). Paralleling means: (1) linking together in real time different stages of R&D, for example basic research and experimental development, and/or (2) linking different sectors, such as universities and firms. As mentioned earlier, the ‘triple helix’ model of Etzkowitz and Leydesdorff (2000, pp. 109, 111) stresses the interaction between academia, state and industry, focusing consequently on ‘university–industry–government relations’ and ‘tri-lateral networks and hybrid organizations’. Carayannis and Laget (2004, pp. 17, 19) emphasize the importance of cross-national and cross-sectoral research collaboration by testing these propositions for transatlantic public–private R&D partnerships. Anbari and Umpleby (2006, pp. 27–9) claim that one rationale for establishing research networks lies in the interest of bringing together knowledge producers, but also practitioners, with ‘complementary skills’. Etzkowitz (2003) speaks of the ‘entrepreneurial university’. An effective coupling of university research and business R&D demands, furthermore, the complementary establishment of the entrepreneurial university and the ‘academic firm’ (Campbell and Güttel, 2005, pp. 170–72). Extended ramifications of these discourses also refer to the challenge of designing proper governance regimes for the funding and evaluation of university research (Geuna and Martin, 2003; see also Shapira and Kuhlmann, 2003; Campbell, 1999, 2003). Furthermore, this imposes consequences on structures and performance of universities (Pfeffer, 2006). Interesting also is the concept of ‘democratizing innovation’, used by Eric von Hippel in his ‘user-centric innovation’ model, in which ‘lead users’ represent ‘innovating users’, who again contribute crucially to the performance of innovation systems. ‘Lead users’ can be individuals or firms. Users often innovate, because they cannot find in the market what they want or need (Von Hippel, 1995, 2005). Non-proprietary knowledge, such as the ‘open source’ movement

in the software industry (Steinmueller, 2004, p.240), may be seen as successful examples for gloCally self-organizing ‘user communities’.

In summary, one could set up the following hypothesis for discussion: while Mode 1 and perhaps also the concept of ‘technology life cycles’ (see Cardullo, 1999; Tasse, 2001) appear to be more closely associated with the linear innovation model, the Mode 2 and triple helix knowledge modes have more in common with a non-linear understanding of knowledge and innovation. At the same time we should add that national (multi-level) innovation systems are challenged by the fact that several technology life cycles, at different stages of market maturity (closeness to commercial market introduction), perform in parallel. This parallel, as well as sequentially time-lagged unfolding of technology life cycles, also expresses characteristics of Mode 2 and of non-linear innovation, because organizations (firms and universities) must often must develop strategies of simultaneously cross-linking different technology life cycles. Universities and firms (commercial and academic firms) must balance the non-triviality of a fluid pluralism of technology life cycles.

2.3 From Triple to Quadruple Helix

Knowledge and innovation policies and strategies must acknowledge the important role of the ‘public’ in achieving goals and objectives. On the one hand, public reality is being constructed and communicated by the media and the media system. On the other hand, the public is also influenced by culture and values. Knowledge and innovation policy should aim to reflect the dynamics of ‘media-based democracy’, to draft policy strategies. Particularly when we assume that traditional economic policy gradually (partially) converts into innovation policy, leveraging knowledge for economic performance and thus linking the political system with the economy, then innovation policy should communicate its objectives and rationales, via the media, to the public to seek legitimation and justification (see Figure 1.9; see also Carayannis and Campbell, 2006a, p.18; 2006b, p.335). Also the PR (public relations) strategies of companies engaged in R&D must reflect on the fact of a ‘reality construction’ by the media. Culture and values also express a key role. Cultural artifacts, such as movies, can influence public opinion of the public and their willingness to support public R&D investment. Some of the technical and engineering curricula at universities are not gender-symmetric, because a majority of the students are male. Trying to make women more interested in enrolling in technical and engineering studies would also imply changing the ‘social images’ of technology in society. The sustainable backing and reinforcing of knowledge and innovation in the gloCal knowledge economy and



Source: Carayannis and Campbell (2006a).

Figure 1.9 Different societal system: lines of political (policy) influence

society requires substantive support of the development and evolution of ‘innovation cultures’ (Kuhlmann, 2001, p.954). Therefore the successful engineering of knowledge and innovation policies and/or strategies leverages the self-logic of the media system and leverages or alters culture and values.

2.4 Coexistence and Co-evolution of Different Knowledge and Innovation Paradigms

Discussing the evolution of scientific theories, Thomas S. Kuhn (1962) introduced the concept of ‘paradigms’. Paradigms can be understood as basic fundamentals upon which a theory rests. In that sense paradigms are axiomatic premises that guide a theory but cannot be explained by the

theory itself. However, paradigms add to the explanatory power of theories that are interested in explaining the (outside) world. They represent something like beliefs. According to Kuhn, scientific theories evolve following a specific pattern: there are periods of 'normal science', interrupted by intervals of 'revolutionary science' again converting into 'normal science', again challenged by 'revolutionary science', and so on (Carayannis, 1993, 1994, 2000, 2001; see also Umpleby, 2005, pp. 287–8). According to Kuhn, every scientific theory, with its associated paradigm(s), has only a limited capacity for explaining the world. Confronted with phenomena that cannot be explained, a gradual modification of the same theory might be sufficient. However, at one point a revolutionary transformation is necessary, demanding that a whole set of theories/paradigms be replaced by new theories/paradigms. For a while, the new theories/paradigms are adequately advanced. However, in the long run, these cycles of periods of normal science and intervals of revolutionary science represent the dominant pattern.

Kuhn emphasizes this shift of one set of theories and paradigms to a new set, meaning that new theories and paradigms represent not so much an evolutionary offspring, but actually replace the earlier theories and paradigms. While this is certainly often true, particularly in the natural sciences, we want to stress that there also can be a coexistence and co-evolution of paradigms (and theories), implying that paradigms and theories can learn from each other. Particularly in the social sciences this notion of coexistence and co-evolution of paradigms might sometimes be more appropriate than the replacement of paradigms. For the social sciences, and politics in general, we can point to the pattern of a permanent mutual contest between ideas. Umpleby (1997, p. 635), for instance, emphasizes the following aspect of the social sciences: 'Theories of social systems, when acted upon, change social systems.' Not only (social) scientific theories refer to paradigms, also other social contexts or factors can be understood as being based on paradigms: we can speak of ideological paradigms or of policy paradigms (Hall, 1993). Another example would be the long-term competition and fluctuation between the welfare-state and the free-market paradigms (with regard to the metrics of left–right placement of political parties in Europe, see Volkens and Klingemann, 2002, p. 158).

These different modes of innovation and knowledge creation, diffusion and use, which we discussed earlier, can also be understood as linking to knowledge paradigms. Because knowledge and innovation systems clearly relate to the context of a (multi-level) society, the (epistemic) knowledge paradigms can be regarded as belonging to the 'family of social sciences'. Interestingly, Mode 2 addresses 'social accountability and reflexivity' as

one of its key characteristics (Gibbons et al., 1994, pp. 7, 167–8). In addition to the possibility that a specific knowledge paradigm is replaced by a new knowledge paradigm, the relationship between different knowledge and innovation modes may often be described as an ongoing and continuous interaction of a dynamic coexistence and (over time) a co-evolution of different knowledge paradigms. This reinforces the understanding that, in the advanced knowledge-based societies and economies, linear and non-linear innovation models can operate in parallel.

2.5 The ‘Co-opetitive’ Networking of Knowledge Creation, Diffusion and Use

Knowledge systems are highly complex, dynamic and adaptive. To begin with, there exists a conceptual (hybrid) overlapping between multi-level knowledge and multi-level innovation systems. Multi-level systems proceed simultaneously at the global, transnational, national, and sub-national levels, creating gloCal (global and local) challenges. Advanced knowledge systems should demonstrate the flexibility to integrate different knowledge modes – on the one hand, combining linear and non-linear innovation modes; on the other hand, conceptually integrating the modes of Mode 1, Mode 2 and triple helix (for an overview of Mode 1, Mode 2, triple helix, and technology life cycles, see Campbell, 2006a, pp. 71–5). This shows the practical usefulness of an understanding of a coexistence and co-evolution of different knowledge paradigms, and what the qualities of an ‘innovation ecosystem’ could or even should be. The elastic integration of different modes of knowledge creation, diffusion and use should generate synergistic surplus effects of additionality. Hence for advanced knowledge systems, networks and networking are important (Carayannis and Alexander, 1999b; Carayannis and Campbell, 2006b, pp. 334–9; for a general discussion of networks and complexity, see also Rycroft and Kash, 1999).

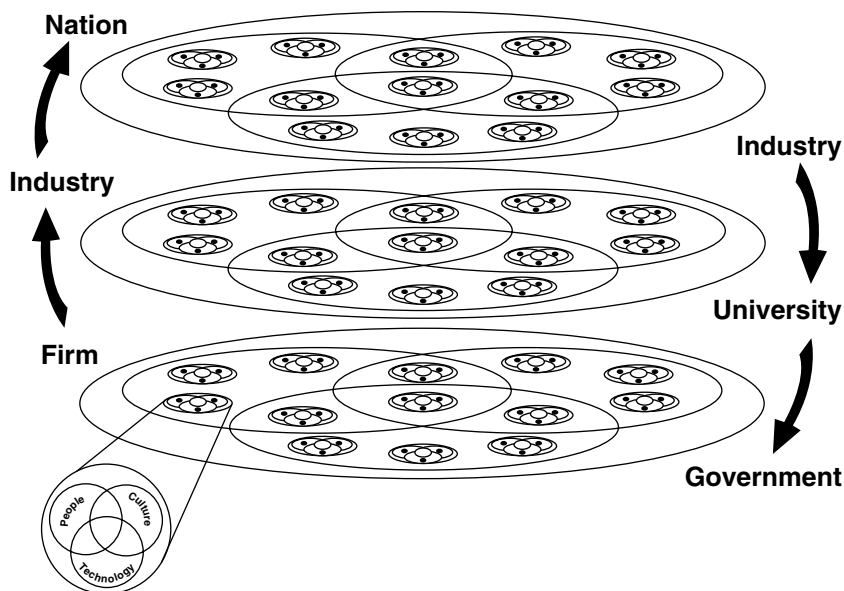
How do networks relate to cooperation and competition? ‘Co-opetition’, as a concept (Brandenburger and Nalebuff, 1997) underscores that there can always exist a complex balance of cooperation and/or competition. Market concepts emphasize a competitive dynamics process between (1) forces of supply and demand, and (2) the need to integrate market-based as well as resource-based views of business activity. To be exact, networks do not replace market dynamics, thus they do not represent an alternative to the market-economy principle of competition. Instead, networks apply a ‘co-opetitive’ rationale, meaning: internally, networks are based primarily on cooperation, but may also allow a ‘within’ competition. The relationship between different networks can be guided by a motivation for

cooperation. However, in practical terms, competition in knowledge and innovation will often be carried out between different and flexibly configured networks. While a network cooperates internally, it may compete externally. In short, 'co-opetition' should be regarded as a driver for networks, implying that the specific content of cooperation and competition is always decided in a case-specific context.

3. CONCLUSION

The Mode 3 systems approach (the innovation ecosystem) to knowledge creation, diffusion and use emphasizes the following key elements (Carayannis and Campbell, 2006c):

1. *GloCal multi-level knowledge and innovation systems* Because of its comprehensive flexibility and explanatory power, systems theory is regarded as suitable for framing knowledge and innovation in the context of multi-level knowledge and innovation systems (Carayannis and Von Zedtwitz, 2005; Carayannis and Campbell, 2006c; Carayannis and Sipp, 2006). GloCal expresses the simultaneous processing of knowledge and innovation at different levels (e.g. global, national and sub-national; see Gerybadze and Reger, 1999; Von Zedtwitz and Gassmann, 2002), and also refers to stocks and flows of knowledge with local meaning and global reach. Knowledge and innovation systems (and concepts) express a substantial degree of hybrid overlapping, meaning that often the same empirical information or case could be discussed under the headings of knowledge or innovation.
2. *Elements/clusters and rationales/networks* In a theoretical understanding, we pointed to the possibility of linking the elements of a system with clusters and the rationale of a system with networks. Clusters and networks are common and useful terms for the analysis of knowledge.
3. *Knowledge clusters, innovation networks and co-opetition* More specifically, we emphasized the terms knowledge clusters and innovation networks (Carayannis and Sipp, 2006). Clusters, by taking demands of a knowledge-based society and economy seriously for a competitive and effective business performance, should be represented as knowledge configurations. Knowledge clusters, therefore, represent a further evolutionary development of geographical (spatial) and sectoral clusters. Innovation networks, internally driving and operating knowledge clusters or cross-cutting and cross-connecting different knowledge clusters, enhance the dynamics of knowledge



Source: Carayannis (2000–2011).

Figure 1.10 The innovation ecosystem

and innovation systems. Networks always express a pattern of co-competition, reflecting a specific balance of cooperation and competition. Intra-network and inter-network relations are based on a mix of cooperation and competition, that is co-opetition (Brandenburger and Nalebuff, 1997). When we speak of competition, it will often be a contest between different network configurations.

4. *Knowledge fractals* These emphasize the continuum-like bottom–up and top–down progress of complexity. Each sub-component (sub-element) of a knowledge cluster and innovation network can be seen as a micro-level sub-configuration of knowledge clusters and innovation networks (see Figure 1.10). At the same time, one can also move upward. Every knowledge cluster and innovation network can also be understood as a sub-component (sub-element) of a larger macro-level knowledge cluster or innovation network – in other words, innovation meta-networks and knowledge meta-clusters.
5. *The adaptive integration and co-evolution of different knowledge and innovation modes, the ‘quadruple helix’* Mode 3 allows and emphasizes the coexistence and co-evolution of different knowledge and innovation paradigms. A key hypothesis is: The competitiveness and

superiority of a knowledge system is highly determined by its adaptive capacity to combine and integrate different knowledge and innovation modes via co-evolution, co-specialization and co-opetition knowledge stock and flow dynamics (e.g. Mode 1, Mode 2, triple helix, linear and non-linear innovation). The specific context (circumstances, demands, configurations, cases) determines which knowledge and innovation mode (multi-modal), at which level (multi-level), involving what parties or agents (multi-lateral) and with what knowledge nodes or knowledge clusters (multi-nodal) will be appropriate. What results is an emerging fractal knowledge and innovation ecosystem well configured for the knowledge economy and society challenges and opportunities of the twenty-first century by being endowed with mutually complementary and reinforcing as well as dynamically co-evolving, co-specializing and co-opeting, diverse and heterogeneous configurations of knowledge creation, diffusion and use. The intrinsic litmus test of the capacity of such an ecosystem to survive and prosper in the context of continually globalizing and intensifying competition represents the ultimate competitiveness benchmark with regard to the robustness and quality of the ecosystem's knowledge and innovation architecture and topology as it manifests itself in the form of a knowledge value-adding chain. The concept of the quadruple helix broadens our understanding because it adds the 'media-based and culture-based public' to the picture.

The societal embeddedness of knowledge represents a theme that Mode 2 and the triple helix explicitly acknowledge. As a last thought for this chapter we want to underscore the potentially beneficial cross-references between democracy and knowledge for a better understanding of knowledge. Democracy could be seen as an interplay of two principles (Campbell, 2005): (1) as a method or procedure based on the application of the rule of the majority (see Schumpeter, 1942). This acknowledges the 'relativity of truth' and 'pluralism' in a society, implying that decisions are carried out, not because they are 'right' (or more right), but because they are backed and legitimized by a majority. Since, over time, these majority preferences normally change, this creates political swings, driving the government/opposition cycles, which crucially add to the viability of a democratic system. (2) Democracy can also be understood as a substance, where understood as an evolutionary manifestation of fundamental rights (O'Donnell, 2004, pp. 26–7, 47, 54–5). Obviously, the method/procedure and the substance approach overlap. Without fundamental rights, the majority rule could neutralize or even destroy itself. On the other hand, the 'real political' implementation of rights also demands a political method,

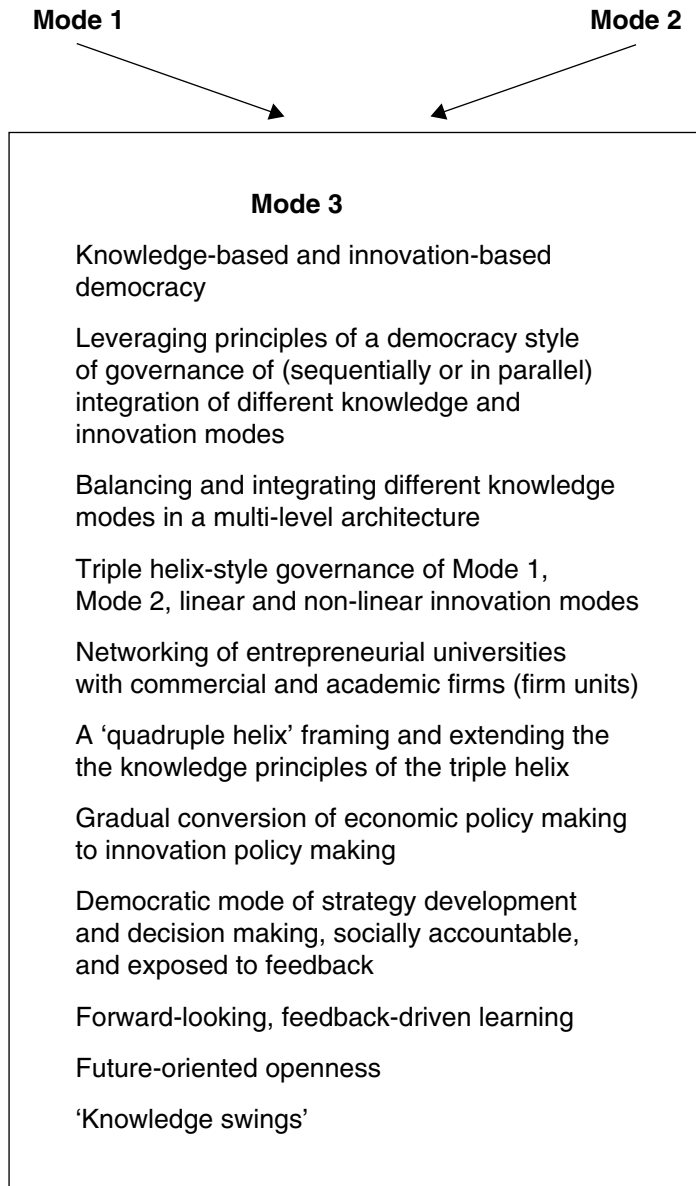
an institutionally set-up procedure. For the purpose of bridging democracy with knowledge and innovation, we highlight the following aspects (see Figure 1.11 for a suggested visualization; see also Godoe, 2007, p. 358; Carayannis and Ziemnowicz, 2007):

1. *Knowledge-based and innovation-based democracy* The future of democracy depends on evolving, enhancing and ideally perfecting the concepts of a knowledge-based and innovation-based democratic polity as the manifestation and operationalization of what one might consider the 'twenty-first-century platonic ideal state':

It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition – one which has made the United States great – that new frontiers shall be made accessible for development by all American citizens. (Bush, 1945, p. 10)

Knowledge, innovation and democracy interrelate. Advances in democracy and advances in knowledge and innovation express mutual dependencies.⁷ The 'quality of democracy' depends on a knowledge base. We see how the gloCal knowledge economy and society and the quality of democracy intertwine. Concepts such as 'democratizing innovation' (Von Hippel, 2005) underscore such aspects. Also the media-based and culture-based public of the quadruple helix emphasizes the overlapping tendencies of democracy and knowledge.⁸

2. *Pluralism of knowledge modes* Democracy's strength lies exactly in its capacity for allowing and balancing different parties, politicians, ideologies, values and policies, an ability discussed by Lindblom (1959) as disjointed incrementalism,⁹ as the partisan mutual adjustment process. Just as entrepreneurs and consumers can conduct their buying and selling without anyone attempting to calculate the overall level of prices or outputs for the economy as a whole, Lindblom argued, so in politics. In many conditions adjustments among competing partisans will yield more sensible policies than are likely to be achieved by centralized decision makers relying on analysis (Lindblom, 1959, 1965). This is partly because interaction economizes on precisely the factors on which humans are short, such as time and understanding, while analysis requires their profligate consumption. To put this differently, the lynchpin of Lindblom's thinking was that analysis could be – and should be – 'no more than an adjunct to interaction in political life' (<http://www.rpi.edu/~woodhe/docs/redner.724.htm>). Similarly, democracy enables the integrating, coexistence and co-evolution of



Source: Carayannis and Campbell (2009).

Figure 1.11 Knowledge, innovation and democracy. GloCal governance styles of the gloCal knowledge economy and society?

different knowledge and innovation modes. We can speak of a pluralism of knowledge modes, and can regard this as a competitiveness feature of the whole system. Different knowledge modes can be linked to different knowledge decisions and knowledge policies, reflecting the communication skills of specific knowledge producers and knowledge users to convince other audiences of decision makers.

3. *Knowledge swings* Through political cycles or *swings* (Campbell, 1992) a democracy ties together different features: (a) decides who currently governs; (b) gives the opposition a chance to come to power in the future; and (c) acknowledges pluralism. Democracy represents a system that always creates and is being driven by an important momentum. For example, the statistical probability of governing parties to lose an upcoming election is higher than to win an election (Müller and Strøm, 2000, p. 589). Similarly, one could paraphrase the momentum of political swings by referring to ‘knowledge swings’: in certain periods and concrete contexts, a specific set of knowledge modes expresses a ‘dominant design’ position; however, the pool of non-hegemonic knowledge modes is also necessary for allowing alternative approaches in the long run, adding crucially to the variability of the whole system. Knowledge swings raise at least two issues: (a) What are dominant and non-dominant knowledge modes in a specific context? (b) There is a pluralism of knowledge modes, which exist in parallel, and thus also co-develop and co-evolve. Diversity is necessary to draw a cyclically patterned dominance of knowledge modes.
4. *Forward-looking, feedback-driven learning* Democracy should be regarded as a future-oriented governance system, fostering and relying upon social, economic and technological learning. The ‘Mode 3 FREIE’ is at its core an open, adaptive, learning-driven knowledge and innovation ecosystem reflecting the philosophy of strategic or active incrementalism (Carayannis, 1993, 1994, 1999, 2000, 2001) and the strategic management of technological learning (Carayannis, 1999; see also De Geus, 1988). In addition, one can postulate that the government/opposition cycle in politics represents a feedback-driven learning and mutual adaptation process. In this context, a democratic system can be perceived as a pendulum with a shifting pivot point reflecting the evolving, adapting dominant worldviews of the polity as they are shaped by the mutually interacting and influencing citizens and the dominant designs of the underlying cultures and technological paradigms (Carayannis, 2001, pp. 26–7).

In conclusion, we have attempted to provide an emerging conceptual framework to serve as the ‘creative whiteboard space’ of ‘knowl-

edge weavers' across disciplines and sectors as they strive to tackle the twenty-first-century challenges and opportunities for socio-economic prosperity and cultural renaissance based on knowledge and innovation.

NOTES

1. The notion of fractals comes from geometry to define objects that are irregular and appear 'broken up': some have a self-similar structure and can describe situations that cannot be explained by classical geometry. In relation to knowledge they help to explain non-linearities (see Carayannis, 2001; Carayannis and Campbell, 2011; Gleick, 1987).
2. See also Milbergs (2005).
3. See discussion on democracy in the conclusion of this chapter.
4. 'Culture is the invisible force behind the tangibles and observables in any organization, a social energy that moves people to act. Culture is to the organization what personality is to the individual – a hidden, yet unifying theme that provides meaning, direction, and mobilization' (Killman, 1985, p.65–8).
5. Technology is defined as that 'which allows one to engage in a certain activity . . . with consistent quality of output', the 'art of science and the science of art' (Carayannis, 2001, p.82–3) or 'the science of crafts' (Braun, 1997, 97–9).
6. In that context also the mutual overlapping between R&D, S&T and ICT (information and communication technology) should be stressed.
7. For attempts to analyze the quality of a democracy, see for example Campbell and Schaller (2002).
8. On 'democratic innovation', see also Saward (2006).
9. Developed by Lindblom (1959, 1965) and Lindblom and Cohen (1979), this approach found several fields of application: 'The Incrementalist approach was one response to the challenge of the 1960s. This is the theory of Charles Lindblom, which he described as "partisan mutual adjustment" or disjointed incrementalism. Developed as an alternative to RCP, this theory claims that public policy is actually accomplished through decentralized bargaining in a free market and a democratic political economy' (<http://www3.sympatico.ca/david.macleod/PTHRY.HTM>).

REFERENCES

- Anbari, Frank T. and Stuart A. Umpleby (2006), 'Productive research teams and knowledge generation', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp.26–38.
- Brandenburger, Adam M. and Barry J. Nalebuff (1997), *Co-Opetition*, New York: Doubleday.
- Braun, C.F. von (1997), *The Innovation War*, Upper Saddle River, NJ: Prentice Hall.
- Bush, Vannevar (1945), *Science: The Endless Frontier*, Washington, DC: US Government Printing Office, <http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm#transmittal>.
- Campbell, David F.J. (1992), 'Die Dynamik der politischen Links-Rechts-Schwingungen in Österreich: Die Ergebnisse einer Expertenbefragung', *Österreichische Zeitschrift für Politikwissenschaft*, **21**(2), 165–79.

- Campbell, David F.J. (1994), 'European nation-state under pressure: national fragmentation or the evolution of supranational structures?', *Cybernetics and Systems: An International Journal*, **25**(6), 879–909.
- Campbell, David F.J. (1999), 'Evaluation universitärer Forschung. Entwicklungstrends und neue Strategiemuster für wissenschaftsbasierte Gesellschaften', *SWR-Rundschau*, **39**(4), 363–83.
- Campbell, David F.J. (2000), 'Forschungspolitische Trends in wissenschaftsbasierten Gesellschaften. Strategiemuster für entwickelte Wirtschaftssysteme', *Wirtschaftspolitische Blätter*, **47**(2), 130–43.
- Campbell, David F.J. (2001), 'Politische Steuerung über öffentliche Förderung universitärer Forschung? Systemtheoretische Überlegungen zu Forschungs- und Technologiepolitik', *Österreichische Zeitschrift für Politikwissenschaft*, **30**(4), 425–38.
- Campbell, David F.J. (2003), 'The evaluation of university research in the United Kingdom and the Netherlands, Germany and Austria', in Philip Shapira and Stefan Kuhlmann (eds), *Learning from Science and Technology Policy Evaluation: Experiences from the United States and Europe*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 98–131.
- Campbell, David F.J. (2005), 'Demokratie, Demokratiequalität und Grundrechte: Ein Vergleich der Fiedler- und EU-Verfassung', Vienna: unpublished manuscript.
- Campbell, David F. J. (2006a), 'The university/business research networks in science and technology: knowledge production trends in the United States, European Union and Japan', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp. 67–100.
- Campbell, David F.J. (2006b), 'Nationale Forschungssysteme im Vergleich. Strukturen, Herausforderungen und Entwicklungsoptionen', *Österreichische Zeitschrift für Politikwissenschaft*, **35**(1), 25–44, <http://www.oezp.at/oezp/online/online.htm>.
- Campbell, David F.J. and Christian Schaller (eds) (2002), *Demokratiequalität in Österreich. Zustand und Entwicklungsperspektiven*, Opladen: Leske + Budrich, http://www.oegpw.at/sek_agora/publikationen.htm.
- Campbell, David F.J. and Wolfgang H. Güttel (2005), 'Knowledge production of firms: research networks and the "scientification" of business R&D', *International Journal of Technology Management*, **31**(1/2), 152–75.
- Carayannis, Elias G. (1993), 'Incrementalisme stratégique', *Le Progrès Technique* (no. 2), Paris: France.
- Carayannis, Elias G. (1994), 'Gestion stratégique de l'apprentissage technologique', *Le Progrès Technique* (no. 2), Paris: France.
- Carayannis, Elias G. (1999), 'Knowledge transfer through technological hyper-learning in five industries', *International Journal of Technovation*, **19**(3), 141–61.
- Carayannis, Elias G. (2000), 'Investigation and validation of technological learning versus market performance', *International Journal of Technovation*, **20**(7), 389–400.
- Carayannis, Elias G. (2001), *The Strategic Management of Technological Learning*, Boca Raton, FL: CRC Press.
- Carayannis, Elias G. and Jeffrey Alexander (1999a), 'Winning by co-opting in strategic government–university–industry (GUI) Partnerships: the power of

- complex, dynamic knowledge network', *Journal of Technology Transfer*, **24**(2/3), 197–210.
- Carayannis, Elias G. and Jeffrey Alexander (1999b), 'Technology-driven strategic alliances: tools for learning and knowledge exchange in a positive-sum world', in Richard C. Dorf (ed.), *The Technology Management Handbook*, Boca Raton, FL: CRC Press, pp. 1-32–1-41.
- Carayannis, Elias G. and M. Allbritton (1997), 'Collaborating in cyberspace: a case study of computer-mediated communication among 100 scholars in 15 countries', *Online Journal of Internet Banking and Commerce*, <http://www.arraydev.com/commerce/jibc/9806-07.htm>.
- Carayannis, Elias G. and Jeffrey Alexander (2004), 'Strategy, structure and performance issues of pre-competitive R&D consortia: insights and lessons learned', *IEEE Transactions of Engineering Management*, **52**(2), 376–85.
- Carayannis, Elias G. and Jeffrey M. Alexander (2006), *Global and Local Knowledge. Glocal Transatlantic Public–Private Partnerships for Research and Technological Development*, Basingstoke: Palgrave Macmillan.
- Carayannis, Elias G. and David F.J. Campbell (2006a), "'Mode 3": meaning and implications from a knowledge systems perspective', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp. 1–25.
- Carayannis, Elias G. and David F.J. Campbell (2006b), 'Conclusion: key insights and lessons learned for policy and practice', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp. 331–41.
- Carayannis, Elias G. and David F.J. Campbell (2006c), 'Introduction and chapter summaries', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp. ix–xxvi.
- Carayannis, Elias G. and David F.J. Campbell (2009), "'Mode 3" and "quadruple helix": toward a 21st century fractal innovation ecosystem', *International Journal of Technology Management*, **46**(3/4), 201–34.
- Carayannis, Elias G. and David F.J. Campbell (2010), 'Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology', *International Journal of Social Ecology and Sustainable Development*, **1**(1), 41–69.
- Carayannis, Elias G. and David F.J. Campbell (2011), 'Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the "Mode 3" knowledge production system', *Journal of the Knowledge Economy*, **2**(3), 327–72.
- Carayannis, Elias G. and Edgar Gonzalez (2003), 'Creativity and innovation = competitiveness? When, how, and why', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation*, vol. 1, Amsterdam: Pergamon, pp. 587–606.
- Carayannis, Elias G. and Patrice Laget (2004), 'Transatlantic innovation

- infrastructure networks: public–private, EU–US R&D partnerships’, *R&D Management*, **34**(1), 17–31.
- Carayannis, Elias G. and Caroline Sipp (2006), *E-Development toward the Knowledge Economy: Leveraging Technology, Innovation and Entrepreneurship for ‘Smart Development’*, Basingstoke: Palgrave Macmillan.
- Carayannis, Elias G. and Maximilian von Zedtwitz (2005), ‘Architecting gloCal (global–local), real–virtual incubator networks (G–RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies’, *Technovation*, **25**, 95–110.
- Carayannis, Elias G. and Christopher Ziemnowicz (eds) (2007), *Rediscovering Schumpeter. Creative Destruction Evolving into ‘Mode 3’*, Basingstoke: Palgrave Macmillan.
- Carayannis, Elias G. and John E. Spillan and Christopher Ziemnowicz (2007), ‘Introduction: why Joseph Schumpeter’s creative destruction? Everything has changed’, in Elias G. Carayannis and Christopher Ziemnowicz (eds), *Rediscovering Schumpeter. Creative Destruction Evolving into ‘Mode 3’*, Basingstoke: Palgrave Macmillan, pp. 1–5.
- Cardullo, Mario W. (1999), ‘Technology life cycles’, in Richard C. Dorf (ed.), *The Technology Management Handbook*, Boca Raton, FL: CRC Press, pp 3–44–3–49.
- Cesaroni, Fabrizio, Alfonso Gambardella, Walter Garcia-Fontes and Myriam Mariani (2004), ‘The chemical sectoral system: firms, markets, institutions and the processes of knowledge creation and diffusion’, in Franco Malerba (ed.), *Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge: Cambridge University Press, pp. 121–54.
- Cooper, G. (1998), ‘Cognitive load theory & instructional design an UNSW’, dwb4.unl.edu/Diss/Cooper/UNSW.htm.
- De Geus, A. (1988), ‘Planning as Learning’, *Harvard Business Review*, **66**(2), 70–71.
- Drejer, Anders (2002), ‘Situation for innovation management: towards a contingency model’, *European Journal of Innovation Management*, **5**(1).
- Etzkowitz, Henry (2003), ‘Research groups as “quasi-firms”: the invention of the entrepreneurial university’, *Research Policy*, **32**, 109–21.
- Etzkowitz, Henry and Loet Leydesdorff (2000), ‘The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–government relations’, *Research Policy*, **29**, 109–23.
- Florida, Richard (2004), *The Rise of the Creative Class: And How It’s Transforming Work, Leisure, Community, and Everyday Life*, Cambridge, MA: Basic Books.
- Gerybadze, Alexander and Guido Reger (1999), ‘Globalization of R&D: recent changes in the management of innovation in transnational corporations’, *Research Policy*, **28**, 251–74.
- Geuna, Aldo and Ben R. Martin (2003), ‘University research evaluation and funding: an international comparison’, *Minerva*, **41**, 277–304.
- Gibbons, Michael, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott and Martin Trow (1994), *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies*, London: Sage.
- Gleick, James (1987), *Chaos: Making a New Science*, New York: Viking Press.
- Godoe, Helge (2007), ‘Doing innovative research: “Mode 3” and methodological challenges in leveraging the best of three worlds’, in Elias G. Carayannis and Christopher Ziemnowicz (eds), *Rediscovering Schumpeter. Creative Destruction Evolving into ‘Mode 3’*, Basingstoke: Palgrave Macmillan, pp. 344–61.

- Hall, Peter A. (1993), 'Policy paradigms, social learning, and the state. The case of economic policymaking in Britain', *Comparative Politics*, April, 257–96.
- Hooghe, Liesbet and Gary Marks (2001), *Multi-Level Governance and European Integration*, Lanham, MD: Rowman & Littlefield.
- Kaiser, Robert and Heiko Prange (2004), 'The reconfiguration of national innovation systems – the example of German biotechnology', *Research Policy*, **33**, 395–408.
- Killman, R. (1985), *Gaining Control of the Corporate Culture*, New York: McGraw-Hill.
- Kline, S.J. and N. Rosenberg (1986), 'An overview of innovation', in R. Landau and N. Rosenberg (eds), *The Positive Sum Strategy*, Washington, DC: National Academy Press, p. 283.
- Kuhlmann, Stefan (2001), 'Future governance of innovation policy in Europe – three scenarios', *Research Policy*, **30**, 953–76.
- Kuhn, Thomas S. (1962), *The Structure of Scientific Revolutions*, Chicago, IL: The University of Chicago Press.
- Lindblom, Charles E. (1959), 'The science of muddling through', *Public Administration Review*, **19**, 79–88.
- Lindblom, Charles E. (1965), *The Intelligence of Democracy*, New York: The Free Press.
- Lindblom, Charles E. and David K. Cohen (1979), *Usable Knowledge: Social Science and Social Problem Solving*, New Haven, CT: Yale University Press.
- Lundvall, Bengt-Åke (ed.) (1992), *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers.
- Malerba, Franco (ed.) (2004), *Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge: Cambridge University Press.
- McKelvey, Maureen, Luigi Orsenigo and Fabio Pammolli (2004), 'Pharmaceuticals analyzed through the lens of a sectoral innovation system', in Franco Malerba (ed.), *Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge: Cambridge University Press, pp. 73–120.
- Milbergs, Egils (2005), *Innovation Ecosystems and Prosperity*, Center for Accelerating Innovation, <http://www.innovationecosystems.com>.
- Miyata, Yukio (2003), 'An analysis of research and innovative activities of universities in the United States', in Larisa V. Shavinina (ed.), *The International Handbook on Innovation*, Amsterdam: Pergamon, pp. 715–38.
- Müller, Wolfgang C. and Kaare Strøm (2000), 'Conclusion: coalition governance in Western Europe', in Wolfgang C. Müller and Kaare Strøm (eds), *Coalition Governments in Western Europe*, pp. 559–92.
- Nelson, Richard R. (ed.) (1993), *National Innovation Systems. A Comparative Analysis*, Oxford: Oxford University Press.
- Nelson, Richard R. and Sidney G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: The Belknap Press.
- Nowotny, Helga, Peter Scott and Michael Gibbons (2001), *Re-thinking Science. Knowledge and the Public in an Age of Uncertainty*, Cambridge: Polity Press.
- Nowotny, Helga, Peter Scott and Michael Gibbons (2003), 'Mode 2 revisited: the new production of knowledge', *Minerva*, **41**, 179–94.
- O'Donnell, Guillermo (2004), 'Human development, human rights, and democracy', in Guillermo O'Donnell, Jorge Vargas Cullell and Osvaldo M. Iazzetta

- (eds), *The Quality of Democracy. Theory and Applications*, Notre Dame, IN: University of Notre Dame Press, pp.9–92.
- OECD (1994), *Frascati Manual. The Measurement of Scientific and Technological Activities. Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: OECD.
- OECD (1998), *Science, Technology and Industry Outlook*, Paris: OECD.
- OECD (2006), *Research and Development Statistics*, (online database), Paris: OECD.
- Pfeffer, Thomas (2006), 'Virtualization of research universities. Raising the right questions to address key functions of the institution', in Elias G. Carayannis and David F. J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp.307–30.
- Rogers, E.M and F.F. Shoemaker (1971), *Communication of Innovations: A Cross-cultural Approach*, New York: Free Press.
- Rogers, E.M., E.G. Carayannis, K. Kurihara and M.M. Allbritton (1998), 'Cooperative research and development of agreements (CRADAs) as technology transfer mechanisms', *R&D Management*, **28**, 79–89.
- Rycroft, Robert W. and Don E. Kash (1999), *The Complexity Challenge. Technological Innovation for the 21st Century*, London: Pinter.
- Saward, Michael (ed.) (2006), *Democratic Innovation: Deliberation, Representation and Association*, London: Routledge.
- Schumpeter, Joseph A. (1942), *Capitalism, Socialism and Democracy*, New York: Harper & Brothers.
- Shapira, Philip and Stefan Kuhlmann (eds) (2003), *Learning from Science and Technology Policy Evaluation. Experiences from the United States and Europe*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
- Shavinina, Larisa V. (2003), *The International Handbook on Innovation*, Amsterdam: Pergamon.
- Steinmueller, W. Edward (2004), 'The European software sectoral system of innovation', in Franco Malerba (ed.), *Sectoral Systems of Innovation. Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge: Cambridge University Press, pp.193–242.
- Tassey, Gregory (2001), 'R&D policy models and data needs', in Maryann P. Feldman and Albert N. Link (eds), *Innovation Policy in the Knowledge-Based Economy*, Boston, MA: Kluwer Academic Publishers, pp.37–71.
- Tornazky, Louis G. and Mitchell Fleischer (1990), *The Processes of Technological Innovation*, Lexington, MA: DC Heath.
- Umpleby, Stuart A. (1997), 'Cybernetics of conceptual systems', *Cybernetics and Systems: An International Journal*, **28**, 635–52.
- Umpleby, Stuart A. (2005), 'What I learned from Heinz von Foerster about the Construction of science', *Kybernetes*, **34**(1/2), 278–94.
- Volkens, Andrea and Hans-Dieter Klingemann (2002), 'Parties, ideologies, and issues. Stability and change in fifteen European party systems 1945–1998', in Kurt Richard Luther and Ferdinand Müller-Rommel (eds), *Political Parties in the New Europe. Political and Analytical Challenges*, Oxford: Oxford University Press, pp.143–67.
- Von Hippel, Eric (1995), *The Sources of Innovation*, Oxford: Oxford University Press.
- Von Hippel, Eric (2005), *Democratizing Innovation*, Cambridge, MA: MIT Press.

- Von Zedtwitz, Max and Oliver Gassmann (2002), 'Market versus technology drive in R&D internationalization: four different patterns of managing research and development', *Research Policy*, **31**(4), 569–88.
- Von Zedtwitz, Max and Philip Heimann (2006), 'Innovation in clusters and the liability of foreignness of international R&D', in Elias G. Carayannis and David F.J. Campbell (eds), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, Westport, CT: Praeger, pp. 101–22.
- Zaltman, Gerald et al. (1973), *Innovations and Organizations*, New York: John Wiley & Sons.

2. Patterns of innovation and the determinants of the diffusion process in selected EU member states

George M. Korres

1. INTRODUCTION

Technological change is the result of both research and imitation activities. As soon as the information about the advantages provided by the innovation becomes available to the potential adopter, the adoption will take place.

Adoption is the result of a complex process of decision making. Absorption is just the process of diffusion perceived from the perspective of the recipient of the technique. The adoption of a new technology is in fact part of a broader process of technological change. Diffusion, defined as a sequence of adoption lags, is fully explained by the characteristics of the spreading of the information. Much attention has been paid to the identification of the determinants of the diffusion of the demand side and the determinants of the supply side.

Diffusion can be analysed as the process of delayed adoptions and imitations of a given innovation, with fixed economic characteristics, including the performances and the price, occurring because of dynamics on the demand side. The main engine is a well-known epidemic contagion in a population of heterogeneous agents, characterized by information asymmetries, and the eventual decay of information costs for potential adopters, driven by the dissemination of information carried out by all those who have already adopted (Griliches, 1957).

This chapter examines the diffusion process and reviews its patterns and determinants. In addition, it examines and reviews the main models and also investigates the correlation between adoption, innovation activities, the diffusion process and the growth process.

2. ADOPTION AND THE DIFFUSION PROCESS

The distinction between innovation and imitation was first introduced by Joseph Schumpeter (1934) and eventually became a landmark in the economics of innovation and new technology.

A new technology, either a new product or a new process, is first introduced by an innovator and eventually imitated by competitors. Imitators copy the innovation and in so doing enter the market and reduce the excess profits of the innovator. Imitation restores perfect competition. The economics of diffusion addresses relevant questions about the characteristics and the determinants, and the effects of the diffusion process. What is most controversial is why imitation is not instantaneous and all firms do not adopt it at the same time (Stoneman, 1976, 1983, 1986, 2002).

Adoption and innovation are two complementary aspects of a broader process of reaction to the mismatch between expectations and facts, and eventual introduction of technological changes that build upon the creative adoption and recombination of internal and external technological knowledge. The identification of the role of adoption costs paves the way for the distinction between gross and net profitability of adoption. Adoption costs are defined by the broad range of activities necessary to identify an innovation and adapt it to the existing production process. Adoption costs include the costs of search and adaptive research, the costs of scrapping the existing fixed production factors, the restructuring of the production and marketing organizations, the re-skilling of personnel, the actual purchase of the capital good and intermediary input embodying the new knowledge, the purchase of patents and licences and the costs of technical assistance (Amendola and Perrucci, 1985, 1986).

Net profitability of adoption is the result of the algebraic sum of the gross profitability engendered by the adoption of an innovation and the costs that it is necessary to incur in order to identify, select and finally adapt the new technology to the existing production conditions (Antonelli, 1990).

Figure 2.1 illustrates that the positive and constant slope of adoption costs is associated with the number of adopters and the positive, but decreasing, slope of the gross profitability of adoption is also associated with the number of adopters, the net profitability. The rate of diffusion will be influenced by the adoption costs and gross profitability of adoption, and also by the dynamics of technological change (Korres, 2011).

The distinction between diffusion within final consumers and diffusion within firms makes it possible to stress the related distinction between gross and net profitability of adoption and the identification of its costs. The distinction between net and gross profitability together with an

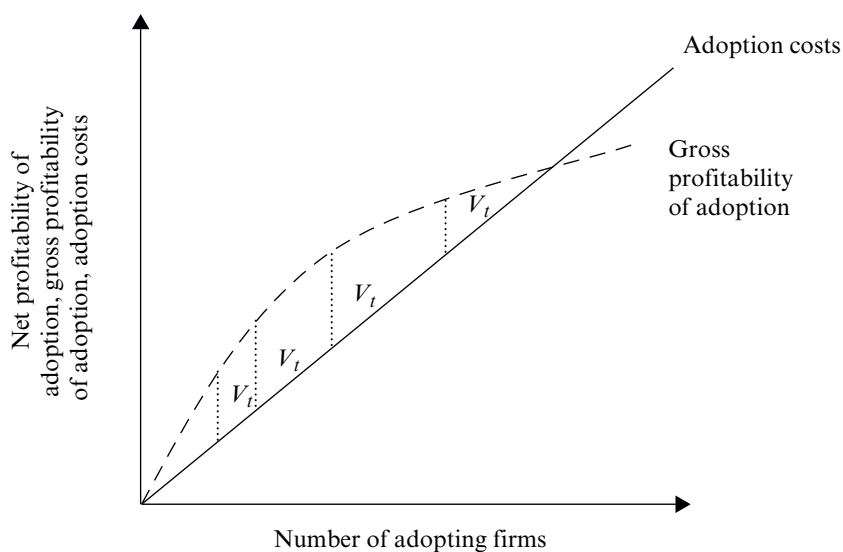


Figure 2.1 Adoption costs, gross net profitability of adoption and diffusion process

understanding of their dynamics, including the effects of the stocks of adoption on the evolution of the net profitability of adoption, provides an analytical probe that combines the demand and supply tradition of analysis of diffusion and shows the complementarity between innovation and adoption within the context of the economics of technological change (Korres, 2011).

3. THE DETERMINANTS AND THE PATTERNS OF DIFFUSION MODELS

The literature on diffusion of technology incorporates the best-known 'inter-industry innovation approach' pioneered by Mansfield (1961, 1988). This approach attempts to study diffusion as one or more innovations in a number of industries, and tries to explain empirically the variance of the speed of diffusion in terms of differences in the attributes of the industries and innovations concerned. Box 2.1 illustrates the main determinants of the demand and supply sides of innovation diffusion.

According to Schumpeter (1934), the diffusion process of major innovations is the driving force behind the trade cycle (the long-term Kondratieff cycle). However, the forces driving the diffusion process *per se* are not

BOX 2.1 DETERMINANTS OF INNOVATION DIFFUSION

Demand side:

- Investment in human capital (increases ability to adopt innovations)
- Investment in R&D (increases ability to adopt innovations)
- The level of prior related knowledge owned by the firm adopting the innovation
- The balance between specialization and diversity in order to absorb external knowledge
- Organizational innovation, ability of users to make organizational changes, kind of organizational structure
- The size of the firms
- Market characteristics of potential users; share of the market; market dynamism; demand growth; number of previous adopters in the market

Supply side:

- R&D and innovation capacity of new-technology suppliers
- The financial means (advertising costs, users' guide etc.)
- Interaction between users and suppliers
- Exchanges of tangible and intangible assets, i.e. trade, FDI, face-to-face contacts, labour mobility etc.
- ICT facilitates awareness about the new technology
- Market structure: horizontal integration favours flows of tangible and intangible assets
- Geographical concentration facilitates awareness of the new technology
- Role played by the standardization procedures
- Insurance system
- IPRs (intellectual property rights)
- Competition
- Integration of the economies

Source: Suriñach et al. (2009).

made explicit. The idea is that the entrepreneur innovates and the attractiveness of attaining a similarly increased profit and similar cost reduction encourages others to imitate; this imitation represents a diffusion process.

The Schumpeterian approach investigated and tried to explain long waves in economic activity (the Kondratieff cycle). The Schumpeterian hypothesis is concerned with the implications of new technology on the economy. In Schumpeterian theory, the entrepreneur introduces innovations and the resulting profits give the signal for imitation by other entrepreneurs. The introduction of new technologies results in the reduction of factor and product prices. The change of prices will induce non-adopters to use the new technology (Korres et al., 2003).

Diffusion of technology can be defined as the process by which the use of an innovation spreads and grows. Diffusion is very important for the process of technological change. On the one hand, it narrows the technological gap between the economic units of an industry, and thus the rate of diffusion determines to a large extent the rate of technological change measured as the effect of an innovation on productivity increase in an industry. On the other hand, diffusion plays an important part in the competitiveness process in the sense that it blunts the competitive edge maintained by the originator of successful innovations. Schumpeter has classified technological change in the following steps (Korres, 2011):

- (a) invention;
- (b) innovation; and
- (c) diffusion.

Diffusion is the last step in the economic impact of a new product or process. It is the stage in which a new product or process comes into widespread use. Figure 2.2 illustrates the importance of diffusion in the process of technological change (Chen, 1983; Korres, 2011). Most literature on diffusion is focused on the theoretical arguments underlying the traditional S-shaped epidemic diffusion curve (Korres, 2011).

4. REVIEW OF THEORY AND EVIDENCE

4.1 The Epidemic Model and the Logistic Curve

Many diffusion models (e.g. Davies, 1979; Stoneman, 1987) are based on the approach of the theory of epidemics. Epidemic models can be used to explain how innovation spreads from one unit to others, at what speed and what can stop it. The epidemic approach starts with the assumption that

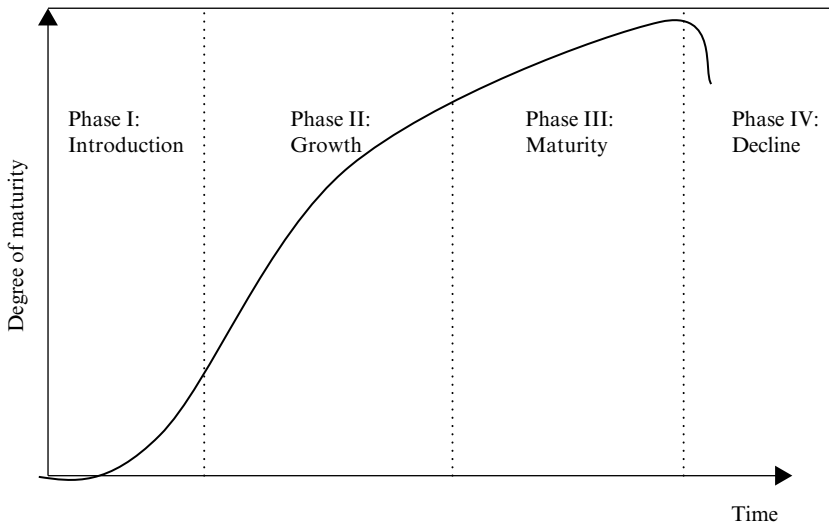
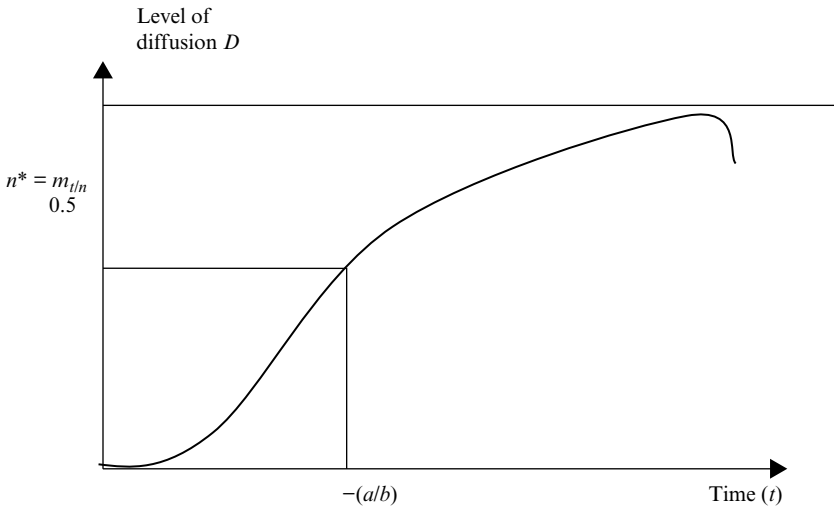


Figure 2.2 The S-shaped curve: the diffusion and growth process

the diffusion process is similar to the spread of a disease among a given population. The basic epidemic model is based on three assumptions:

- the potential number of adopters may not be in each case the whole population under consideration;
- the way in which information is spread may not be uniform and homogeneous;
- the probability of optimizing innovation once informed is not independent of economic considerations, such as profitability and market perspectives.

The epidemic model is based on the idea that the spread of information about a new technology is the key to explaining diffusion. Epidemic models hypothesize that some firms adopt later than others because they do not have sufficient information about the new technology. According to this theory, potential adopters initially have little or no information about the new technology and are therefore unable or disinclined to adopt it. However, as diffusion proceeds, non-adopters glean technical information from adopters via day-to-day interactions, just as one may contract a disease by casual contact with an infected person. As a result, as the number of adopters grows, the dissemination of information accelerates, and the speed of diffusion increases.



Notes: (a/b) = spread of new technology; D = level of diffusion; n = total firms in a population; m_t = number of adopters in a population; $n-m_t$ = number of potential adopters in a population.

Figure 2.3 The logistic epidemic curve

The spread of new technology among a fixed number of identical firms can be represented as follows. Let us assume that the level of diffusion is D , which corresponds to m_t number of firms in a fixed population of n which have adopted the new innovation at time t and to $(n-m_t)$ firms that remain as the potential adopters. Figure 2.3 illustrates the logistic epidemic curve. There is a huge literature on the law of logistic growth, which must be measured in appropriate units. Different studies on plants and animals were found to follow the logistic law, even though these two variables cannot be subject to the same distribution. Population theory relies on logistic extrapolations. The only trouble with this theory is that not only the logistic distribution but also the normal, the Cauchy, and other distributions can be fitted to the same material with the same or better goodness of fit. Examining the logistic curve, we can summarize the following disadvantages:

- the infectiousness of the disease must remain constant over time for all individuals; this means that b must be constant; however, in the case of a reduction in the contagiousness of the disease, b falls over time;
- all individuals must have an equal chance of catching the disease.

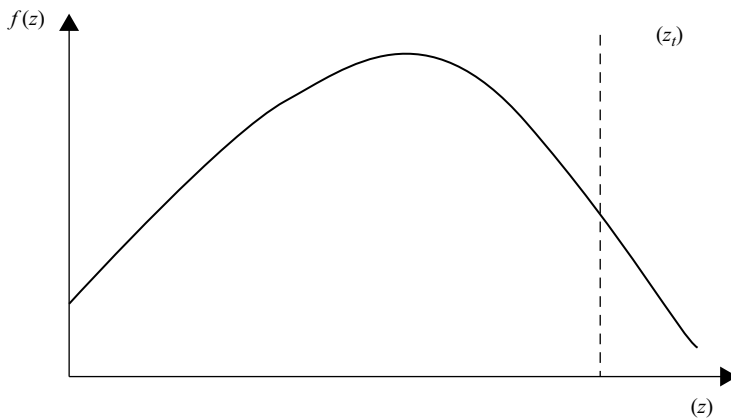
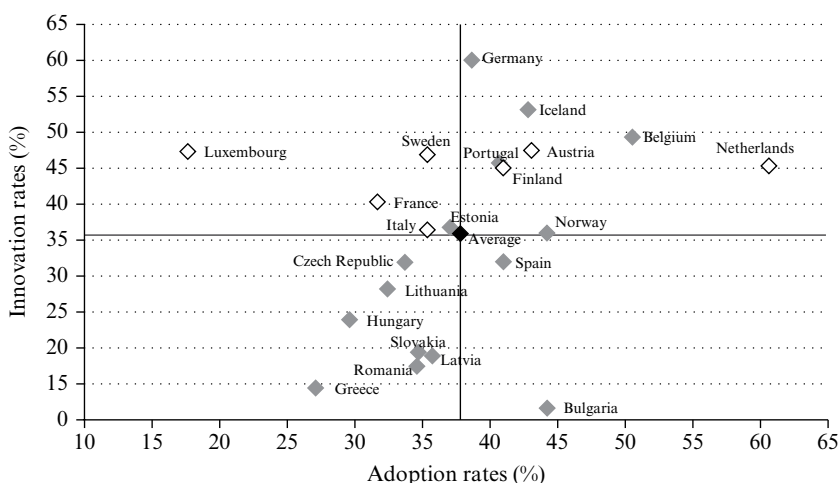


Figure 2.4 The cumulative distribution

4.2 The Probit Models

Probit analysis is a well-established technique in the study of diffusion of new products between individuals. This approach concentrates on the characteristics of individuals in a sector and is suitable not only to generate a diffusion curve, but also to give some indication of which firms will be early adopters and which late. Given the difficulties associated with the linear probability model, it is natural to transform the original model in such a way that predictions will lie between the (0,1) interval for all X . These requirements suggest the use of a cumulative probability function (F) in order to be able to explain a dichotomous dependent variable (the range of the cumulative probability function is the (0,1) interval, since all probabilities lie between 0 and 1).

The probit probability model is associated with the cumulative normal probability function. The central assumption underlying the probit model is that an individual consumer (or a firm/country) will be found to own the new product (or to adopt the new innovation) at a particular time when the income (or the size) exceeds some critical level. Let us assume that the potential adopters of technology differ according to some specified characteristic, z , that is distributed across the population as $f(z)$ with a cumulative distribution $F(z)$, as Figure 2.4 illustrates. The advantage of the probit diffusion models is that they relate to the possibility of introducing behavioural assumptions concerning the individual firm (firms). The probit model also offers interesting insights into the slowness of the technological diffusion process.



Note: The average adoption rate given in the figure (and in the following figures) is computed as an average of the country rates and not as a global rate computed from the country and industry database.

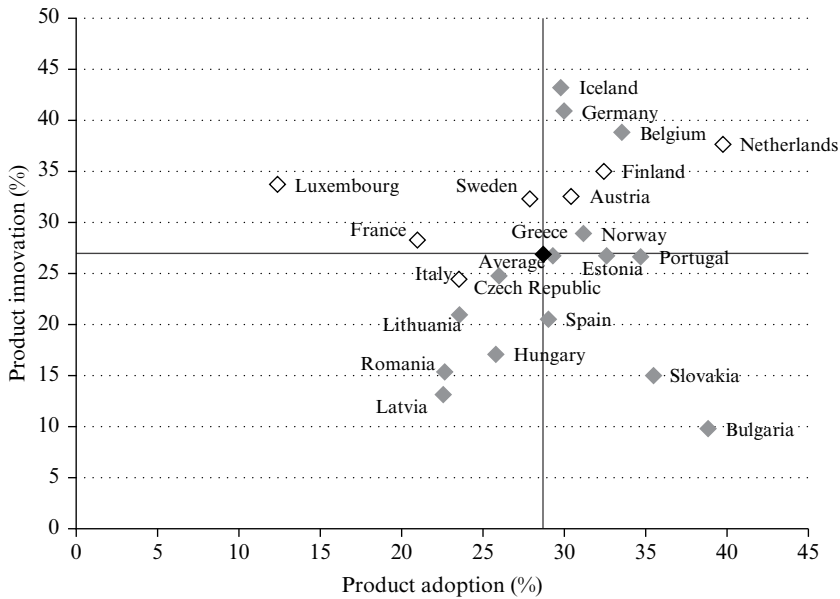
Source: Suriñach et al. (2009).

Figure 2.5 Innovation and adoption rates by selected member states

Furthermore, a number of economists (such as Mansfield, 1961; Sahal, 1977) consider diffusion as a disequilibrium phenomenon. Usually, when a new technology or a new method is introduced, it is less developed than the older method with which it competes. Therefore it is likely to have greater potential for improvement and for reduction in cost. The introduction of a new product or process broadens the range of choice of producers and consumers, and the equilibrium is altered. In the real world, there is only a gradual adjustment over the course of time to the new equilibrium level.

4.3 Diffusion and Adoption Process: Evidence from European Member States

The performance of innovation adoption for European member states seems to be more important for process innovations than for product innovations. Cooperation activities drive innovation adoption at the EU level while the acquisition of innovations from external innovators is a less important source of adoption of innovation (both process and product). Figures 2.5–2.7 illustrate the innovation and adoption rates by



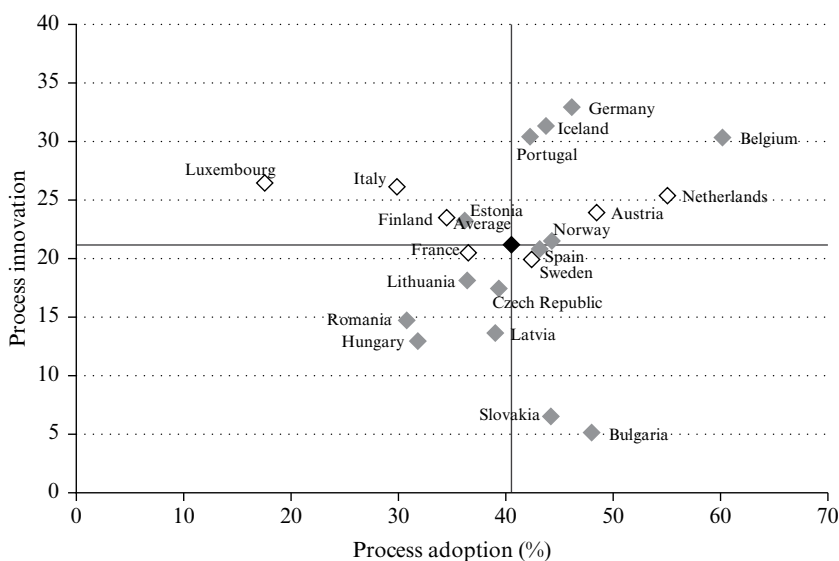
Source: Suriñach et al. (2009).

Figure 2.6 Product innovation and product adoption by member states

member states, product innovation and the product adoption by member states, and process innovation and process adoption by member states, respectively.

The most important features of the diffusion process of innovation activities are, according to Suriñach et al. (2009):

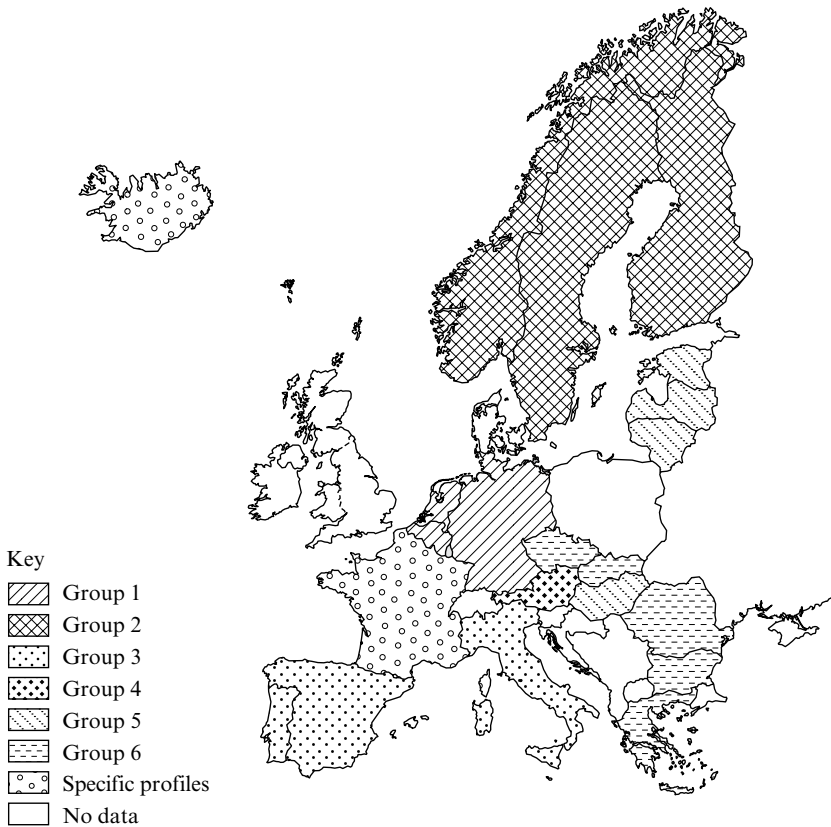
- For all European states, the adoption rate is higher in the case of process innovation (41 per cent) than product innovation (28 per cent). So, innovation adoption is more process oriented (even if innovation on its own is more product-oriented, 24 per cent of EU firms make process innovations versus 28 per cent that perform product innovations).
- Innovation adoption rates vary substantially across EU member states. The highly innovative countries seem also to be those that are more engaged in adoption activities. Luxembourg has a high rate of innovation but the adoption rate is very low. This feature can also be observed for France and Sweden but to a lesser extent. Bulgaria has a very low innovation rate but an important adoption rate.



Source: Suriñach et al. (2009).

Figure 2.7 Process innovation and process adoption by selected member states

- The average percentage of adoptive firms is equal to 39 per cent; this rate varies a great deal according to countries. The maximum value is observed for the Netherlands with 61 per cent, then for Belgium with 51 per cent. On the contrary, the minimum value is observed for Luxembourg with 18 per cent. This percentage is low if compared to other countries since all other values are between 27 per cent and 44 per cent.
- The member states with low innovation rate also record a low adoption rate. This applies to Greece and to the majority of Eastern Europe countries (Romania, Latvia, Slovakia and Hungary). On the contrary, countries with high innovation rates have higher adoption rates (such as Belgium, the Netherlands, Iceland, Germany and Austria).
- European member states with higher rates of product innovation also experience higher rates of product adoption (apart from the specific cases of Bulgaria and Luxembourg). The same is true for process innovation activities; those countries innovating more on process are also those that seem to benefit from process innovation adoption.

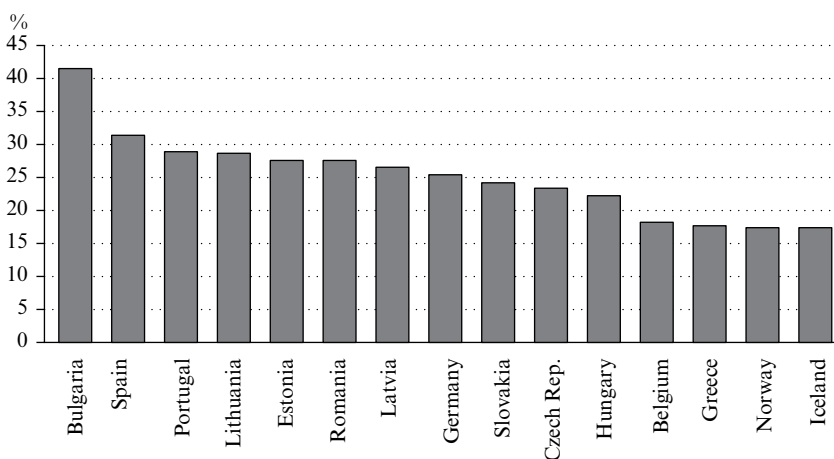


Source: Suriñach et al. (2009).

Figure 2.8 Geographical pattern of EU states according to their adoption and innovation levels

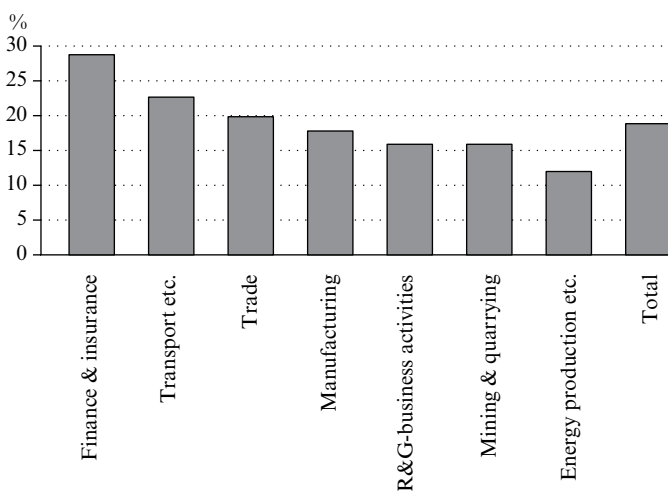
Figure 2.8 illustrates the geographical pattern of EU states according to their adoption and innovation levels. According to these results, groups 1 and 2 face high adoption rates while, on the contrary, groups 5 and 6, which differ in their innovative and general economic features, register low adoption rates.

Figures 2.9–2.11 illustrate the share of sales due to adoption, the share of both product and process adopting firms by sector and also the innovation adoption rates in the EU, respectively. Regarding the adoption behaviour in the sectoral case, we can state the following facts (Suriñachi et al. 2009):



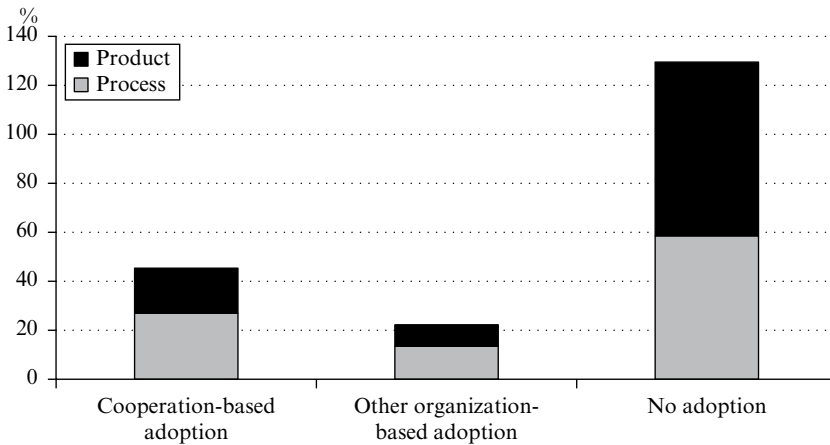
Source: Eurostat.

Figure 2.9 Share of sales due to adoption (based on 'new to the firm' definition of adoption)



Source: Eurostat.

Figure 2.10 Share of both product and process adopting firms over total adopting firms by sector



Source: Eurostat.

Figure 2.11 Innovation adoption rates in the EU

- For both product and process innovations, cooperation rates are particularly high for wholesale trade, financial activities and transport and communication (and energy only for process innovation adoption). On the contrary, manufacturing and extractive industry record the lowest rates.
- Whatever the sector and the nature of innovation (product or process), cooperation is more frequent than outsourcing to other organizations.
- The adoption is more cooperation-based for process innovation than product innovation, whatever the sector.

5. SUMMARY

New technologies imply some micro effects (on firms and organizations) and some macro effects (on industrial sectors) for the whole economy. In addition, new technologies play an important role in the productivity and competitiveness of a country. For instance, the faster the technological progress, the faster should the factor productivity rise and the less should 'cost-push' exert upward pressure on the price level. The principal effects for technological policy can be distinguished on the demand and supply sides.

Diffusion is the spread of a technology through a society or industry.

The diffusion of a technology generally follows an S-shaped curve as early versions of technology are rather unsuccessful, followed by a period of successful innovation with high levels of adoption, and finally a dropping off in adoption as a technology reaches its maximum potential in a market.

Most of the empirical literature focuses on the impact of innovation diffusion on economic growth. In addition, most of the literature analyses the determinants of innovation adoption, both micro and macro level. Also, countries with a higher level of innovative activities seem to be also those more dynamic in the context of innovation adoption. It is clear that fostering innovation activities may also be associated to some extent with spillover effects (which can take place through 'adoption mechanisms') leading to higher levels of diffusion and adoption of innovation.

For any innovation, the costs of entry for the innovator can be represented as the sum of the following components: the fixed investment cost in plant and equipment; the cost incurred by the innovator in acquiring scientific and technical knowledge not possessed by the firm at the beginning of innovation process; the cost incurred by the innovator in acquiring the relevant experience (know-how in organization, management, marketing or other areas) required to carry the innovation through; and the cost borne by the innovator to compensate for whatever relevant externalities are not provided by the environment in which the firm operates. Imitators will compare the cost of buying the technology with the cost of developing it themselves, if they can. However, the imitators' knowledge related to the entry costs will depend crucially on their own initial scientific and technical knowledge base in the relevant areas. Consequently, the entry costs may be much higher or much lower than the innovators, depending on their relative starting positions in the knowledge level of the firm. Furthermore, government regulations, taxes, tariffs and other relevant policies will strongly affect environmental and actual costs for an innovator. Specifically, the difficulty of catching up for industries/firms in the developing countries exists because scientific and technical knowledge, practical experience and locational advantages may be lower than in the more advanced countries, while those of technology may be higher.

REFERENCES

- Amendola, G. and Perrucci, A. (1985), 'The diffusion of an organizational innovation: international data telecommunications and multinational industrial firms', *International Journal of Industrial Organisation*, **3**: 109–18.

- Amendola, G. and Perrucci, A. (1986), 'The international diffusion of new information technologies', *Research Policy*, **15**: 139–47.
- Antonelli, C. (1990), 'Induced adoption and externalities in the regional diffusion of new information technology', *Regional Studies*, **24**: 31–40.
- Chen, E. (1983), 'The diffusion of technology', in *Multinational Corporations, Technology and Employment*, Basingstoke: Palgrave Macmillan, ch. 4.
- Davies, S. (1979), *The Diffusion of Process Innovations*, Cambridge: Cambridge University Press.
- Griliches, Z. (1957), 'Hybrid corn: an exploration in the economics of technological change', *Econometrica*, **25**: 501–22.
- Korres, G. (2011), *Handbook of Innovation Economics*, New York: Nova Publishers.
- Korres, G., Lionaki, I. and Polychronopoulos, G. (2003), 'The role of technical change and diffusion in the Schumpeterian lines', in Jürgen Backhaus (ed.), *Joseph Alois Schumpeter: Entrepreneurship – Style and Vision*, New York: Kluwer Academic Publishers, pp. 293–312.
- Mansfield, E. (1961), 'Technical change and the rate of imitation', *Econometrica*, **29**: 741–65.
- Mansfield, E. (1988), 'The speed and cost of industrial innovation in Japan and the United States: external vs. internal technology', *Management Science*, **34**(10): 1157–68.
- Sahal, D. (1977), 'Substitution of mechanical corn pickers by field shelling technology – an econometric analysis', *Technological Forecasting & Social Change*, **10**: 53–60.
- Schumpeter, Joseph A. (1934), *The Theory of Economic Development*, Cambridge, MA: Harvard Economic Studies.
- Stoneman, P. (1976), *Technological Diffusion and the Computer Revolution*, Cambridge: Cambridge University Press.
- Stoneman, P. (1983), *The Economic Analysis of Technological Change*, Oxford: Oxford University Press.
- Stoneman, P. (1986), 'Technological diffusion: the viewpoint of economic theory', *Recherche Economique*, **XL**(4): 585–606.
- Stoneman, P. (1987), *The Economic Analysis of Technology Policy*, Oxford: Oxford University Press.
- Stoneman, P. (2002), *The Economics of Technological Diffusion*, Oxford: Blackwell.
- Suriñach, Jordi, Autant-Bernard, Corinne, Manca, Fabio, Massard, Nadine and Moreno, Rosina (2009), 'The diffusion/adoption of innovation in the internal market', Economic Papers No. 384, September, Directorate-General Economic and Financial Affairs.

3. Building the innovation union: lessons from the 2008 financial crisis

**Alice O. Nakamura, Leonard I. Nakamura and
Masao Nakamura¹**

1. INTRODUCTION

The focus of the Innovation Union initiative of the European Union (EU) is on product and process innovation for tangible goods. We argue that it is essential to extend the scope of the initiative to include innovation for financial sector products, processes and regulatory approaches. We make this argument using examples of financial sector innovations in the USA following the Great Depression and on the basis of an examination of the 2008 financial crisis.

2. THE INNOVATION UNION IN BRIEF

The website for the Competitiveness and Innovation Framework Programme of the European Commission (2010) states:

Innovation is the only means of tackling the major societal challenges such as climate change, scarce natural resources and an aging society, while fostering jobs and growth.

The Europe 2020 strategy and its flagship Innovation Union initiative are based on this perspective. The aim is to spur growth of the EU economy and jobs via enhanced innovation activity. The ultimate goal is to harness innovation in the service of raising EU living standards now and for generations to come (European Commission, 2011a).

There are plans to offer researchers more attractive careers and to remove obstacles to the mobility of researchers across sectors and EU countries. Reforms have been agreed on too for modernizing higher education, including increases in graduate student numbers. Other measures include helping EU students and trainees study abroad and making

Europe's universities more attractive destinations for talent from other nations (European Commission, 2011b).

The Europe 2020 strategy includes multiple programs as well for making the EU a more welcoming region for businesses interested in developing innovative products and processes. For example, intellectual property rights protections are being strengthened and the costs of patenting in Europe are being reduced. Other efforts under way have the goal of improving business access to financing. Especially for young companies, finding suitable investors can be a crucial step towards business expansion and survival. Taken as a share of GDP, venture capital investment in the USA is four times higher than in the EU. The Commission has appointed the Chairman of the British Business Angels Association to head an expert group tasked with formulating recommendations on how to improve the cross-border matching of innovative firms with investors. The expert group findings were presented in 2012 (European Commission, 2011b).

3. SETBACKS ATTRIBUTED TO THE 2008 FINANCIAL CRISIS

The Europe 2020 and Innovative Union programs and plans and objectives make sense, but the lingering effects of the 2008 financial crisis represent an overarching feasibility question mark. In the program documents, it is noted that the EU economy is slowly emerging from the deepest recession in decades and that the economic crisis has resulted in large losses in economic activity in the EU. Millions of jobs have been lost (European Commission, 2011e).

By the end of 2012, it is anticipated that the economies of a large share of the member states will still be operating at output and employment levels below those preceding the crisis. The incidence of people unemployed for more than one year has increased steeply across the EU and youth unemployment exceeds 20 percent in more than half the EU member states.

The financial crisis impact on public finances has been very negative. Government debt-to-GDP ratios have risen sharply in most member states, reflecting both a decline in tax revenues and increased pressures on government expenditure for income support and fiscal stimulus. The crisis has further reduced potential growth via a fall in the investment rate. Business R&D investments have been hit especially hard (European Commission, 2011c).

The profitability outlook for the EU area banks is especially uncertain due to the sluggish recovery, heavy exposure to the real-estate sector, and tensions in the sovereign debt market. The negative feedback from the real

economy to the financial sector has been reinforced in some member states by high household and non-financial corporate sector indebtedness, with the prevalence of non-performing loans increasing considerably.

The EU has established new rules and agencies to try to ensure that all financial players are properly regulated in years to come (European Commission, 2011d). Efforts are under way, in particular, to ensure that EU banks have sufficient capital reserves to withstand future shocks to the financial system while continuing to function and to provide credit to households and businesses. However, stricter leverage rules mean that EU banks will be more constrained in their lending even when more favorable economic growth conditions have been restored.

One way to minimize the impact of the heightened regulatory policies is to improve the ability of financial regulators to monitor financial institutions and instruments, as well as the ability of financial intermediaries to measure and limit their own risks. Indeed, in the USA the Dodd–Frank Act included an Office of Financial Research to specifically accomplish these ends. Part of the charge of the Office of Financial Research is to establish data infrastructure for the study of financial instruments and institutions, and to improve the monitoring capabilities of financial regulators and the financial industry. Nakamura (2011) discusses the value of such a data infrastructure and suggests one framework for it.

The Europe 2020 and the Innovation Union programs and stated goals pertain mostly to boosting R&D for products that are tangible and processes for producing tangible products. There is little mention of basic research aimed at achieving a deeper understanding of the causes of the 2008 financial crisis or that seeks to discover and develop new financial sector products, institutions and regulatory approaches that could help address the post-crisis problems and needs. This state of affairs represents a contrast to US financial innovation activities in the wake of the Great Depression, as explained below, those innovations included new financial products and institutions.

Some see the 2008 financial crisis as a continuation of a pattern documented by Kindleberger and Aliber (2005), who argue that financial crises keep happening because of a recurrent pattern. The authors find that sustained increases in the price level for some asset lead investors to become increasingly optimistic and more eager to pursue speculative profit opportunities while the lenders become less risk-averse. The profit opportunities often arrive as a consequence of the ‘widespread adoption of an invention with pervasive effects – canals, railroads, the automobile – some political event or surprising financial success’ (p. 18). An increasingly large share of asset purchases is undertaken in anticipation of short-term capital gains and a large and growing share of these purchases are financed with credit.

There is a pervasive sense, they argue, that it is ‘time to get on the train before it leaves the station’ and the exceptionally profitable opportunities disappear. Asset prices increase further, fuelled by increasing speculative activity.

Eventually, Kindleberger and Aliber observe, the asset price bubble bursts, and speculators rush to unload their asset holdings, which pushes the asset prices down further. John Geanakoplos (2010) has nicely discussed how a key aspect of these repetitive price increases and declines may be differences in opinion – the optimists hold and increase their asset holdings while the price is rising, because the increase in the value of the assets increases the wealth of the optimists. When the price turns, the optimists lose wealth and must divest. Speculators who made their purchases largely using borrowed funds end up owing more on their loans than the assets can be sold for. Kindleberger and Aliber document repeated historical episodes that follow this pattern: a pattern that fits what happened in the 2008 financial crisis in multiple respects. Nevertheless, we feel that the 2008 financial crisis also involved specific financial products and regulatory problems that require specific attention.

4. THE US FINANCIAL SECTOR

4.1 Financial Institutions Created in the Wake of the Great Depression

Americans were bitter toward and fearful of bankers in the wake of the Great Depression, and the institutions established and rules enacted then reflect those feelings. The 1933 McFadden Act prohibited banks from having branches in more than one state. The 1933 Glass–Steagall Act prohibited depository banks from creating and selling securities. That Act also created the Federal Deposit Insurance Corporation (FDIC), which insures bank deposits. In 1934, the Securities and Exchange Commission (SEC) was established to regulate the nation’s stock and options exchanges and to help prevent corporate abuses in reporting and in the sale of securities.

Also in 1934, Congress created the Federal Housing Administration (FHA)² to help rebuild the US home construction and housing markets by providing insurance on mortgages originated by FHA-approved lenders. Soon after the FHA was established in 1934, the agency moved to create a new sort of mortgage instrument for Americans: a 30-year mortgage with the rate of interest fixed over the full mortgage term, and with the mortgage being prepayable at any time without penalty. As Woodward and Hall (2009) explain, this American mortgage greatly reduced homeowner risks and was instantly popular with homeowners. However, it exposes

any institution that originates and holds mortgages to two sorts of serious risks. Future expected revenue from profits on mortgages already originated can suddenly vanish if interest rates fall and homeowners refinance. Alternatively, if interest rates rise, lenders can end up facing higher rates on short-term funds borrowed to finance the portfolios they are carrying than the rates being paid by homeowners on their mortgages.

On the institutional front, US financial innovations following the Great Depression also included the creation in 1938 of Fannie Mae. Fannie's initial mandate was to borrow funds and then to buy up US government-insured mortgages from private sector mortgage originators (i.e. mortgage lenders). This replenished the funds of the lenders so they could then originate more mortgages. Originally, Fannie held the mortgages purchased in the corporation's portfolio and received income as borrowers repaid the interest and principle. Back then, Fannie's debt from those purchases was fully backed by the US government.

However, governments, like private businesses, often look for accounting and organizational expediencies that can legitimize operation with greater leverage. Thus, in 1954, government backing for Fannie's borrowings was rescinded,³ and in 1968, Fannie's mortgage portfolio was taken off the federal balance sheet entirely. The original Fannie Mae was split in two. One part was renamed and became a new government corporation called Ginnie Mae. Ginnie was given the mission of selling US government-insured mortgages. The other part retained the name of Fannie Mae and became a 100 percent stockholder-owned enterprise. Soon thereafter, in 1970, Freddie Mac was also created by the US government as a 100 percent shareholder-owned enterprise. However, investors clearly continued to believe there was government backing for Fannie and Freddie's debt, and were encouraged in this belief by special privileges accorded to Fannie and Freddie by the US government and special demands that were placed on Fannie and Freddie to help meet national affordable housing objectives.

4.2 The Invention of Mortgage-Backed Securities (MBS) and Securitization

Mortgages have always been hard to sell to investors. Hence the US government department of Housing and Urban Development (HUD) designed a mortgage-backed security (MBS).⁴ An MBS, in its simplest form, is a bond backed by a pool of mortgages on which homeowners are contractually obligated to make regular monthly payments. Those payments are collected monthly and then passed through to the MBS holders.

Soon Ginnie Mae, Fannie Mae and Freddie Mac were all packaging

mortgages into pools and then selling MBSs that were enhanced by agency guarantees against the financial risk of losses due to default. Indeed, investors were guaranteed not just full repayment, but *timely* repayment, though only the guarantees of Ginnie Mae were, in fact, legally backed by the US government.

The private sector took years to develop a competing product that could match the popularity of the MBS that Ginnie, Fannie and Freddie sold. Thus Ginnie, Fannie and Freddie were able to dominate the MBS market through the 1990s. However, by 2001, another financial product innovation called a collateralized debt obligation (CDO) finally made it possible for private firms to compete with the Ginnie–Fannie–Freddie MBS. A CDO consists of a collection of bonds called tranches that are backed by a pool of debt assets which usually includes mortgages, and often also other debt assets such as car loans and credit card accounts.⁵ The payments from the pool flow to the different tranches in order of their seniority.

The most senior tranche, sometimes called super senior, has the highest-priority claim on the mortgage pool cash flows. Once that tranche has been taken care of, then cash is sequentially allocated to fill each of the remaining tranches, in their seniority priority order. The so-called equity investors are those holding the most junior MBS tranches with the lowest cash flow priority and hence the highest risk of losses. However, the equity investors also get the highest rate of return when a CDO does well over time. Investment bank hedge funds turned out to be among the largest of the CDO equity investors.

On 8 April 2005, in his address to the Federal Reserve System's Fourth Annual Community Affairs Research Conference, then Fed Chairman Alan Greenspan declared:

Innovation has brought about a multitude of new products, such as subprime loans and niche credit programs for immigrants . . . With these advances in technology, lenders have taken advantage of credit-scoring models and other techniques for efficiently extending credit to a broader spectrum of consumers . . . The mortgage-backed security helped create a national and even an international market for mortgages, and market support for a wider variety of home mortgage loan products became commonplace. This led to securitization of a variety of other consumer loan products, such as auto and credit card loans.⁶

In this statement, Greenspan is celebrating the financial product innovations of the USA, and especially the development of MBS and CDO. Although some of these products were inadequately regulated and subsequently caused great losses not only in the USA but also in the EU and elsewhere, many of the innovations themselves are clearly success stories.

4.3 Special Investment Vehicles (SIV)

A special investment vehicle (SIV), also referred to by a variety of other names including a special purpose vehicle and a special purpose entity, is a corporate legal entity created by a sponsoring organization to segregate specific activities (risks). By isolating high-risk projects from a parent organization and by allowing new investors to take a share of the very specific segregated risks held by the SIV, it can be easier to attract increased investor participation. An SIV often consists simply of a set of legal documents and has no offices, management or employees. It is also usually ‘bankruptcy remote’, meaning that if the sponsoring organization has financial problems, its creditors cannot seize the assets of the SIV.

A firm can use SIV to finance large R&D and other sorts of risky projects so that these can be pursued without putting the entire firm at risk. This usage of SIV can help increase investor participation in R&D: an EU objective. In addition, however, SIV can be used by firms to avoid future taxes on the returns from R&D and many other sorts of projects that were, in fact, mostly carried out with personnel and other resources located in countries other than where the SIV are located.

Prior to the 2008 financial crisis, SIV had come to be widely used in the creation and sale of asset-backed securities including CDO. In creating a CDO, an SIV is usually created first. The SIV is often established in a tax haven. The SIV issues bonds to investors in exchange for cash, which is then used to purchase the portfolio of assets which will be used for the CDO. The bonds, called tranches, are issued in layers with different risk characteristics, as noted above.

4.4 The US Nationally Recognized Statistical Rating Organizations (NRSRO)

Perhaps because of being especially reliant on capital market funding for many purposes including mortgage funding, the USA has developed the world’s most known and used rating companies for assessing the riskiness of securities traded on financial markets, including debt securities like CDO. A small number of these rating agencies have essentially become part of the US financial sector regulatory system. These are called nationally recognized statistical rating organizations (NRSRO).

The NRSRO first came to be designated this way in 1973. Back then, the US Securities and Exchange Commission (SEC) decided to tie the capital requirements for broker-dealers to ratings for the securities they held. In designing these new regulatory capital requirements, the SEC

worried that if they were designated as NRSRO, some of the many agencies then producing ratings for securities might start essentially selling favorable ratings. Thus the SEC designated just a short list of the established agencies in the securities rating business as NRSRO, and decreed that only the ratings of those agencies could be used for satisfying SEC regulatory capital requirements.⁷

Soon NRSRO ratings began to be incorporated into other rules and regulatory procedures, including the leverage regulations for money market funds, pension funds and insurance companies. In the early 1980s, there were seven NRSROs. In the 1990s, mergers reduced the number to three: Standard & Poor's (S&P), Moody's and the Fitch Group Inc. (Fitch). Those three continue to dominate the NRSRO ratings business, although the number of NRSROs was subsequently increased again by the SEC.

Corporations (including municipalities) that issue securities want NRSRO triple A ratings for their securities because this allows those corporations to raise funds at lower cost. And financial institutions, including banks and funds, have wanted to invest in triple A securities because the regulators for financial institutions in many countries have permitted them to operate with lower capital reserves if they were holding triple A rated securities.⁸ In good times, holding less regulatory capital lets financial institutions achieve higher profit rates.

Soon international guidelines for financial institutions also began to build in NRSRO ratings. Of special importance, in 1988, the Basel Committee on Banking Supervision, an international body made up of representatives from the major central banks, produced the Basel Accord, which went into effect in 1992 in the EU and many other participating countries. The original Basel Accords were superseded in 2004 by Basel II, which was intended to create an international standard for banking regulators to control how much capital banks needed to hold in reserve to guard against financial risks.⁹

From the perspective of a lender, experience suggests that the safest direct loans are home mortgage loans to borrowers with excellent credit and loan amounts that are 80 percent or less of their property values. These loans to 'prime' borrowers had a risk weighting of 35 percent under Basel II. However, when loans of that sort were packaged into a mortgage-backed security rated triple A, the risk weighting under Basel II was only 20 percent! In this way, Basel II reduced the amount of capital a bank had to keep in reserve to back up loans, and thereby increased bank profits so long, of course, as the bank did not end up facing solvency challenges. Thus banks had a strong incentive to sell the mortgage and other consumer loan accounts they originated and to replace holdings of those sorts

of debt assets with triple A debt asset-backed securities. Thus EU area banks loaded up on triple A rated MBS and CDO tranches.¹⁰

The NRSRO credit ratings for securities backed by consumer debt assets are arrived at using the credit rating information for the borrowers for the pooled debt assets.¹¹ Empirical evidence collected in recent years had shown that people with steady track records of paying all their bills on time almost never defaulted on mortgage loans, and this empirical ‘fact’ was built into the CDO rating processes of the NRSRO. By now, however, it was recognized that there is one condition under which mortgage default becomes considerably more likely even for homeowners who, previously, had been regularly paying all their bills on time. This is the situation in which the market value of a home falls below the value of the mortgage: the underwater homeowner case. The NRSRO, along with much of the rest of the finance industry, ended up greatly underestimating the likelihood of default for subprime, and also for prime, mortgages in the underwater case.

4.5 The Use of Credit Default Swaps to Upgrade Mortgage-Backed Securities

Credit default swaps (CDS) are an insurance or a gambling product, depending on how they are used. CDS were invented by a team led by Blythe Masters of JPMorgan in 1997 as a tool for hedging default risk on loans. The cost of a freely traded CDS could potentially provide a better estimate of the risk on a debt instrument than the opinion, say, of a credit rating agency expressed in the form of a credit rating.¹²

With a CDS, the buyer makes a series of payments to the seller and is then entitled to a payment if a specified ‘credit event’ happens, such as a loss of value for the ‘reference entity’ named in the CDS purchased. CDS increasingly were used by those packaging and selling CDO tranches for the purpose of obtaining ratings upgrades for lower-quality securities such as subprime debt assets. Buyers of CDO were especially reassured by CDS sold by companies with triple A ratings from an NRSRO like the American Insurance Group (AIG), the world’s largest insurance company, or a monoline insurance company like Ambac.¹³

The triple A claims-paying record of AIG had been built up over years of selling types of insurance like life insurance with little potential for systemic risk. And the triple A rated monolines had built up their good credit-paying records over the years by just insuring municipal bonds, for which defaults had been rare (Madigan, 2008). It turned out, therefore, that the companies that sold most of the CDS had earned their triple A ratings from the NRSRO for business activities in prior years that were

quite different from the business of insuring CDO. Moreover, AIG was able to avoid holding reserves against the risk of writing the CDS because it argued that the purpose of the CDS was not insurance but simply regulatory arbitrage.

The explosion in the use of CDS to shore up the ratings of CDO backed by mortgages of increasingly dubious quality seems to have been driven by the role that triple A rated securities could play for financial institutions in meeting regulatory capital requirements. In the years prior to 2008, European banks reportedly acquired mortgage and other debt asset-backed securities that were accompanied by more than US\$426 billion in AIG credit default swaps. When AIG's rating fell in September 2008, causing downgrades for all securities for which the rating had been enhanced via a CDS sold by AIG, this left large numbers of European banks holding less than the required levels of capital.

4.6 Synthetic CDO: The Key to Creation of Vastly More Triple A Securities

Increasingly in the years leading up to 2008, CDS were also purchased for purely speculative purposes by buyers without any insurable interest whatsoever in the named credit events for the CDS. These CDS are referred to as naked. A speculator who bought a naked CDS was betting the reference entity written into the CDS would suffer a credit event. Sales of naked CDS to speculators had come to dominate the CDS market by 2008.

Although they had been used for decades to hedge risks, CDS sales had remained limited in earlier years. One reason for this is that, to be useful for regulatory capital purposes, a CDS had to be combined with an asset. For example, a CDS might be used to enhance the rating of a security like a CDO so that it could be held as regulatory capital by a bank. But pools of mortgages were needed to create regular CDO, and the supply of suitable mortgages available for purchase that met the specifications needed for the creation of CDO tranches that could be highly rated if combined with a CDS was limited. However, that limitation was removed with the creation of synthetic CDO.

A synthetic CDO combines newly created CDS with fixed income securities. The latter could be one or more already existing CDO, say. Tranches of synthetic CDO are securities that can be rated, and the highly rated tranches could then be used to satisfy regulatory capital requirements. The term 'synthetic CDO' arises because the cash flows from the premiums (via the included CDS) are analogous in some ways to the 'fixed income' cash flows arising from the mortgage or other debt obligations in the pools backing up regular CDO. However, if a credit event occurs in the

fixed income portfolio part of a synthetic CDO, then the synthetic CDO investors become responsible for the losses, starting from the lowest-rated tranches of the synthetic CDO and working up. With a synthetic CDO, credit losses hurt the investors in the synthetic CDO and benefit the writers of the embedded CDS.

A buyer of a synthetic CDO is taking the 'long' position, meaning they are betting that the referenced fixed income securities will perform well. The seller of a synthetic CDO pays premiums to the buyer so long as there has not been a credit event for the referenced entity. This party is taking the 'short' position, meaning they are betting the referenced securities will default. The seller receives a large payout from the synthetic CDO buyer if the referenced entities have a credit event. While the supply of synthetic CDO was primarily driven by the intense demand for assets with the risk–return characteristics of CDO, the sellers also stood to gain in the event of poor mortgage performance.

4.7 Innovative Changes that Resulted in Increasing Maturity Mismatch

The market for debt securities with a maturity of 13 months or less is generally referred to as the money market. Money market mutual funds have traditionally invested in short-term, low-risk instruments such as government securities, commercial paper, certificates of deposit, repurchase agreements and discount notes. These funds often offer immediate and full redemption of shares to members, but they fund assets that have longer terms and may be costly to liquidate. This innate fragility of money market funds can cause problems for other financial firms and the broader economy because of the size of the money fund industry and its prominence in short-term financing for other financial institutions.

The wholesale money market intermediates cash balances predominantly for institutional investors. These funds are usually raised on a short-term rollover basis (see Pozsar et al., 2010). Maturity transformation refers to the use of funding that is shorter term than the assets being financed. By definition, a financial institution engaging in maturity transformation cannot honor a sudden request for full withdrawals. As the maturity mismatch between a financial institution's debt assets and liabilities grows, the required maturity transformation and associated risks grow too.

Date and Konczal (2010) note that the traditional assets of US commercial banks were relatively illiquid commercial and consumer loans and the traditional funding source for these banks were deposits. Because deposit funding in the USA enjoys some measure of FDIC insurance and is provided by independent, atomized depositors, these funds are not usually

withdrawn en masse in response to shocks to the economy or to a financial institution. This source of funding fits well with the inherently illiquid nature of most consumer and many commercial loans.

In contrast, the US investment banks have traditionally favored inexpensive, short-term funding in the wholesale money markets. This funding derives from relatively few institutional sources. Moreover, over time, the US investment banks increased their exposure to long-term, illiquid assets, while becoming increasingly dependent on the wholesale money market for funding. The maturity of their liabilities declined to as short as a day. Hedge funds, which basically are unregistered investment banks that serve high net worth or institutional investors, became similarly vulnerable. In addition, over time some of the US commercial banks began to also rely heavily on short-term, wholesale money market funding (Huang and Ratnovski, 2011).

Even though Canadian commercial banks have been allowed all along to carry out investment bank activities, Ratnovski and Huang (2009) point out that the Canadian banks have consistently depended less on wholesale funding, and much more on depository funding from households, than many US depository banks. As Bordo et al. (2010) also explain, when Canadian banks do use short-term wholesale funding, they are required to maintain stocks of highly liquid assets appropriate for their cash flow and funding profiles. Banks with more than 10 percent of funding coming from wholesale money market sources have been required in Canada to put in place internal limits on short-term funding requirements.

4.8 Off-Book Budget Items

Off-budget items are part of a broader problem of missing information that the decision makers running private financial firms and the public sector regulators need to be able to effectively do their jobs. The consequences of missing and wrong information are illustrated, for example, in a now public Lehman study completed in the fall of 2007 by company analysts Shilpiekandula and Gorodetsky. Amazingly, these analysts found little cause for concern except for the monolines that had sold large volumes of CDS that had been used to upgrade the ratings of CDO. Beyond that, however, these analysts were mostly clueless about the developing financial market conditions that would soon destroy their company.¹⁴

The Commodity Futures Modernization Act (CFMA), passed on 20 December 2000, exempted derivative transactions, including CDO and CDS sales, from all requirements of exchange trading and clearing. This meant that there were no comprehensive, real-time sources of data about the volumes of CDO and CDS that had been sold (Greenberger, 2010).

Also, Partnoy and Turner (2010) explain that, historically, US accounting rules required corporations to consolidate on their balance sheets any special investment vehicles they used to finance assets. During the 1970s, if a transaction was a financing, both the assets being financed and the financing had to be on the balance sheet. However, over the following decades, those rules were modified so that a corporation only had to include the assets and liabilities of another corporate entity in its financial statements if it had a ‘controlling interest’ in that entity. Accounting standards like this that enable the growth of off-book business activities mess up the economic data used not only for regulation of financial institutions, but also for economic planning.

5. BREAKING THE FINANCIAL CRISIS OF 2008 INTO A CHAIN OF FOUR COMPONENT CRISES

We see the financial crisis of 2008 as a chain reaction of component crises. Recognizing these components may make it easier to understand why extensive financial sector expertise and research are needed as a defense against follow-up financial crises of a similar nature. Poor financial sector outcomes undermine the means of paying for R&D in other sectors.

5.1 Crisis 1: Rising Mortgage Defaults

Mortgage defaults were the trigger for the 2008 crisis. In turn, the waves of mortgage defaults were triggered by the change from rising to falling in the USA of average home prices. Although many argue now that change in the direction of the US home price trend should have been anticipated, the timing of that change clearly came as a surprise to many. It was the change in the direction of the home price trend beginning in 2006 that triggered the mortgage defaults, and those defaults contributed to further and deeper declines in home prices, leading to more defaults. It is understood by now that owners of homes for which the market values have fallen below the values of their mortgages (‘underwater’ homeowners) are likely to default on their mortgages even if those mortgages are classified as prime.¹⁵

The extent of the boom–bust cycle in housing was exacerbated during the boom phase as well, as rising house prices directly lowered the risk of home lending. Borrowers who lack the funds to make their mortgage payments could either borrow additional sums against their increased home equity or sell their homes. This reduction in risk then apparently led to additional reductions in the credit standards of lenders, allowing new

borrowers to raise home demand further in a boom cycle, as described by Brueckner et al. (2012). That is, in addition to failing to foresee when the US average home price would stop rising, the US consumer credit scoring agencies¹⁶ failed to properly take account of the likelihood of loan defaults for underwater homeowners, and this contributed to the US practice of giving mortgages without requiring significant down-payments.

5.2 Crisis 2: The Ratings Downgrades and Value Slides for Mortgage-Backed Securities

The volume of mortgage-backed CDO grew rapidly between 2000 and 2006, and then went into decline once mortgage defaults began to rise. The credit ratings for mortgage-backed securities, including CDO, began to be downgraded by the ratings agencies once the default rate began to rise. Mortgage-backed CDO performed far worse than other types of CDO issued over the years of 1999–2007.¹⁷ Published in January 2007, Moody's report on structured finance ratings over the period of 1983–2006¹⁸ notes that the slowing US housing market and rising interest rates had very negative effects on the ratings of US mortgage-backed securities.

Without a triple A credit rating, a CDO was no longer useful for reducing the regulatory capital requirements for a bank or fund. Financial institutions thus began selling large volumes of their downgraded CDO securities, pushing CDO market values and ratings down further. As CDO prices fell, the trading of CDO became increasingly difficult. This liquidity failure was aggravated by rising margin requirements, which limited the freedom of action for speculative investors and many of them also began trying to unload their CDO holdings. The regulators for financial institutions failed to foresee and guard against the chain reaction of ratings downgrades that ensued (see Benmelech and Dlugosz, 2009; Bartlett, 2010).

5.3 Crisis 3: Downgrades for Credit Default Swap Sellers

When homeowners began to default on their mortgages in record numbers, the owners of CDO who had hedged their risk by CDS, and also the speculators who had placed bets that there would be widespread mortgage defaults by buying naked CDS naming downgrades of mortgage-backed CDO as the named credit events, began to be entitled to collect payouts. However, the sellers of the CDS had not held sufficient capital reserves to deal with large numbers of claims.

In 2008, the financial press was filled with dire news about the CDS sellers. The monolines were the focus of worries back then. It was widely

recognized that they had sold more CDS than they were in a position to back up. The news reports explained that if one or more of the main triple A monolines were downgraded by the rating agencies, a wide range of other financial institutions would also be in trouble.¹⁹

In addition to selling CDS to shore up CDO, the monolines had also collectively guaranteed about \$2.4 trillion worth of municipal bonds. Those CDS guarantees had allowed municipalities to borrow more cheaply. Downgrades for the monolines meant downgrades too for the municipal bonds guaranteed by the monolines. The perceived likelihood of monoline ratings downgrades rose steadily beginning in the summer of 2007.

In January 2008, the credit rating was reduced from triple to double A for Ambac, the largest of the monolines. This caused immediate downgrades of thousands and thousands of municipal bonds, and there were resulting downgrades as well of CDO held by financial institutions. As the major rating agencies began to downgrade other monoline insurers too during 2008, vast numbers of additional municipal bonds, CDO and other securities insured by those companies were downgraded as well. In addition, AIG had also sold far more CDS than the company was in a position to pay out claims on. Thus the CDS crisis rapidly worsened in 2008.

The CDS sellers in the USA should have been regulated under both insurance and bucket shop (i.e. gambling) laws. Unfortunately, the USA explicitly exempted CDS from both those sorts of regulation (Greenberger, 2010). Europe needs to be in a position to notice a US regulatory lapse like this and to take defensive measures.

5.4 Crisis 4: The Collapse of Investment and Some Commercial Banks and Fannie and Freddie

The mortgage defaults, falling CDO values, and downgrades and payout failures of CDS sellers caused the failure of all the main US investment banks. This was the most spectacular manifestation of the 2008 financial crisis. Bear Stearns was the first to fail. On 17 March 2008, the Fed opened a line of credit that enabled JPMorgan to buy Bear for just \$2 a share.²⁰ On 15 September, Lehman Brothers declared bankruptcy. Also on 15 September, Merrill Lynch was purchased by the Bank of America in an emergency deal. Back then, Merrill was the largest US brokerage firm. In addition, on 21 September, the Fed agreed to let Morgan Stanley and Goldman Sachs become bank holding companies, making them eligible for federal aid.²¹

Many other financial giants failed as well that year. For example, in

November, the nation's largest bank holding company, Citigroup, had to be rescued with taxpayer money. The nation's largest mortgage lender, Countrywide Financial, was acquired by Bank of America in a distressed sale, and Bank of America then had to be rescued by the Fed, due in part at least to problem assets acquired along with Merrill Lynch.

Based on a study of 72 large banks and bank holding companies in the OECD, Huang and Ratnovski (2011) conclude that greater reliance on wholesale money market rather than retail depository funding was a key determinant of which banks fared badly in the 2008 financial crisis. The study revealed that many of the US investment and depository banks that got into trouble in the crisis relied heavily on wholesale (and other sorts of) funding that could be withdrawn quickly.²²

Concerns arose as well in 2008 regarding the leverage of Fannie and Freddie and their ability to make good on their guarantees for the MBS those corporations had sold. As part of their capital reserves, they held large portfolios of private label CDO that had lost their original triple A ratings and much of their original market value over the summer of 2008. On 7 September 2008, the federal regulator for Fannie and Freddie put them into conservatorship.²³

Many money market funds had purchased MBS under binding buy-back agreements that were conditional on continued triple A ratings for those assets. Hence a sudden loss of triple A status for large volumes of MBS put those funds at imminent risk too. Risk assessments rose for CDO and MBS. A large portion of these securities were held in various special investment vehicles that relied on asset-backed commercial paper for financing. Doubts on the part of money market fund managers regarding the securities those SIV held led to a market liquidity collapse for asset-backed commercial paper. Banks hoarded liquidity in order to provide sufficient funding for their SIV and drastically reduced their lending.

Following the bankruptcy of Lehman Brothers in 2008, Mora (2010) explains that money market funds were hit by massive redemptions, as were hedge funds, which led to forced asset sales that intensified the downward spiral in asset prices. Instead of offering liquid funds to banks, money market funds began competing with banks for financing. Also, a large number of creditors, including some major hedge funds, had their assets frozen in the Lehman bankruptcy, and were forced to find alternative funds, adding to the selling pressure in equity markets.

The USA allowed its financial system to become very vulnerable to disruptions in the availability of wholesale money market funds. Europe needs to be in a position to notice financial market problems like this and to have ways of limiting EU area contagion.

6. LESSONS FOR THE INNOVATION UNION FROM THE 2008 FINANCIAL CRISIS

The reality of the 2008 financial crisis is that inadequately regulated new financial sector products and practices undermined the financial support for R&D and new product and product market developments in virtually all other sectors of not just the US economy, where both the financial sector innovation and the 2008 financial crisis were rooted, but also the EU economy. A wide slowdown in R&D and in getting new innovative products to market is a perennial consequence of financial crises, regardless of their causes. Public and private sector R&D and the commercial development of new products all predictably diminish in the wake of a large financial crisis because the funding sources dry up. The lesson we draw from this reality is that basic research on financial markets, products and regulation should also be an Innovation Union focus since financial market stability is essential for sustained innovation.

If the EU were playing more of a leadership role in financial sector innovation, this could also increase its weight in international negotiations on financial sector regulation. The US-certified NRSRO provide selective discipline for the financial activities of banks, other companies and even nations in the EU. However, the EU does not seem to have had effective ways of modifying US financial sector activities even when those activities threatened to, or did, have bad consequences for the EU.²⁴ Nor did the EU take effective defensive actions to lessen the impact on the EU of the errors of the US rating agencies and regulators.

7. A RELATED NEED FOR INCLUDING TAX POLICY RESEARCH IN THE INNOVATION UNION AGENDA

R&D expenditure figures play a key role in the performance metrics built into the Innovation Union initiative and the Europe 2020 strategy. Yet the results in a 2010 article by Robert E. Lipsey raise concerns about what is being captured by the national R&D expenditure data being compiled by the EU official statistics system. A related concern is that the hoped-for benefits of the Innovation Union initiative include the projected tax revenues from resulting product sales. Lipsey's results raise concerns about those benefit projections too.

Intangible productive assets often lack clear geographical locations. The firm that owns such assets, if it is a multinational firm, can move them from one member of the multinational group to another, changing the

nominal geographical location without changing the geographical location of the use or the control of the asset. The effect of such a transaction is to shift the apparent location of the production based on that asset. In the process, the firm may change what had been recorded as production in a location into imports to that location.

The geographical assignments by the firm then determine where production based on some assets is reported to take place, and hence the distribution of production across countries, and which sales are measured as exports or imports. As production comes to depend more and more on intangible assets such as patents, copyrights, technological and scientific knowledge, and techniques of management, the location of production by multinational firms will become more and more ambiguous. Yet this is precisely the direction in which the Innovation Union initiative is trying to move EU production, and in which EU and other developed economies are believed to be moving anyway.

Lipsey provides strong empirical evidence that many firms choose the locations of production for intangible productive assets so as to minimize taxes, and that they operate to reduce their measured output in countries with higher tax rates on business income. Lipsey shows that these reporting practices also exaggerate the imports of high-tax countries and understate their exports. The problem in trade data is probably worse for trade in services than for trade in goods, but it exists also for trade in goods, especially of types for which much of the value comes from intangible assets. Lipsey singles out insurance as one of the industries that takes advantage of these opportunities for tax minimization.

Moreover, many of the same problems arise with the location of production based on financial assets of a multinational firm, although the valuations of the assets are more easily defined at least. With a transfer of assets from a parent to an affiliate, or among affiliates, production appears to have shifted its location, but all the other inputs into production may have remained in the former locations.

One sign of distorted measures of output by location is the reporting of high levels of output and profits in locations where there is little labor or tangible capital. Another is the reporting of ratios of output and profits to tangible inputs that differ to an extreme extent from worldwide norms. The inputs for which location is most reliably measured and least likely to be manipulated are of labor and of physical capital in the form of plant and equipment.

For 2004, Lipsey (2010) estimated the exaggeration of the value added, or output, and of sales of US affiliates in eight tax havens. The exaggeration of value added in 2004, estimated from its relation to fixed capital and labor compensation, was \$33 billion, which is about 4 percent of the

worldwide total of affiliate value added. The estimated exaggeration in the sales of these affiliates in that year was almost \$360 billion, which was more than 10 percent of worldwide sales! Since the tax havens examined are relatively small countries, most of the reported sales must have been exports, suggesting an even larger impact on measured exports and imports and the balances of payments.

Hines (2005) claims that much of reported tax haven income consists of financial flows from foreign affiliates that parent companies own indirectly through their tax haven affiliates. He notes that firms in other countries that largely exempt their firms' foreign income from taxation, such as Germany and the Netherlands, have especially strong incentives to locate investment and income production in tax havens (p. 79).

The European Commission has been discussing proposals for a uniform method of allocating income among the countries in which a multinational operates. A paper by Fuest et al. (2007), based on the Deutsche Bundesbank's database on German multinationals' foreign operations and a matched database on the firms' domestic operations, calculated what firms' distributions of taxable income across countries would be under a hypothetical allocation of income based on sales, employment and assets, including tangible and intangible assets. The paper shows large discrepancies between the hypothetical allocated income distribution and the reported one. We see this as an important topic area for research, and institutional and regulatory as well as product innovation. Without progress on this front, much of the hoped-for economic benefits of the Innovation Union could end up being lost as a side effect of the economic conditions that result from financial crises, or could end up mostly benefiting tax havens rather than EU member nations.

8. CONCLUDING REMARKS

Kindleberger studied hundreds of financial crises around the world. The discouraging conclusion he (1993) draws is that most of the rules for sound banking were already incorporated in financial sector regulations long ago, either explicitly or implicitly in the form of financial sector traditions. He asserts that financial crises happen because whatever rules are instituted following each new financial crisis, these soon come to be selectively ignored by financial institutions, regulators and politicians as the expansion phase of the next credit cycle takes hold.

There are signs of what Kindleberger describes as the seeds of the next financial crisis in the making in some aspects of how the Dodd-Frank Act is, and is not, being implemented. On 21 July 2010, President Barack

Obama signed the Dodd–Frank Wall Street Reform and Consumer Protection Act (‘Dodd–Frank Act’) into law. However, Wall Street lobbyists ensured that even under the Dodd–Frank Act, banks are permitted to exclude their full exposure to swaps from their financial statements, and instead report only the ‘fair value’ changes in those swaps over time. Such reporting, Greenberger (2011) argues, is like an individual reporting only the change in their debt balances, instead of the reporting the debts themselves. Yet he also feels that ‘The Act has the potential to effectively regulate the derivatives markets, if regulators make the most of the tools made available to them by Dodd–Frank.’

The crisis that engulfed the financial system of the USA and many of the EU area economies in 2008 has had severe and widespread negative consequences. The R&D activities that the Innovation Union seeks to enhance have been especially hard hit. We argue, therefore, for including in the Innovation Union research aimed at increasing financial sector stability while protecting economic growth. In designing this program of research, it might make sense to examine the Canadian experience and regulatory methods much more carefully (Leblond, 2011). Canada is a nation that has had sustained economic growth and that has a slightly higher proportion of households living in owned housing than the USA, but that has not been vulnerable to banking and other financial sector instability like the USA, going back at least as far as the Great Depression.

NOTES

1. Thanks are due to Karl R. Kopecky of the University of Alberta and a long-time successful investor in financial markets for his help with multiple parts of this chapter, and to Ivan Fellegi, Dennis Fixler, Michael Greenberger and Randall Morck and other participants in a 4 June session of the 2011 meeting of the Canadian Economics Association for comments on an earlier version of the chapter (under a different title). Funding from the Social Sciences and Humanities Research Council of Canada is also gratefully acknowledged. The authors are solely responsible for the opinions expressed and for any errors of fact or interpretation; our views do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or the US Federal Reserve System.
2. http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/fhahistory.
3. This happened with the passage of the Charter Act of 1954.
4. The first mortgage-backed securities (then called ‘passthroughs’) were guaranteed and issued by Fannie Mae and Freddie Mac over the years 1968–71.
5. CDO backed as well by other types of debt assets besides mortgages are often referred to as a type of asset-backed security (ABS). CDO backed only by mortgages are also a type of MBS.
6. Alan Greenspan, Consumer Finance, Remarks at the Federal Reserve System’s Fourth Annual Community Affairs Research Conference, Washington, DC, 8 April 2005, at www.federalreserve.gov/BoardDocs/speeches/2005/20050408/default.htm.
7. <http://www.sec.gov/answers/nrsro.htm>.

8. Moody's denotes its top rating by Aaa. AAA is the top rating for Standard and Poor's. We use the term 'triple A' throughout to denote the top rating.
9. For more on the Basel processes and accords, see http://en.wikipedia.org/wiki/Basel_Committee_on_Banking_Supervision.
10. Basel III represents an attempt to overcome some of these problems. <http://www.moodysanalytics.com/Contact-Us/ERM/Contact-Form-Basel-III-Implementation/~media/Insight/Regulatory/Basel-III/Thought-Leadership/2011/11-01-09-Implementing-Basel-III-Whitepaper.ashx>.
11. Witt (2010) explains several different methods that were used to rate CDO. He was an analyst, and then a managing director in the US derivatives group at Moody's over 2000–2005.
12. The risk-related meaning of a triple A versus, say, a double B rating for a security is hard to quantify. In contrast, a CDS priced at, say, 1.08 percent on an 8 percent bond can be valued using standard financial methods as the equivalent of a risk-free 6.92 percent bond.
13. These are the monoline insurance companies, denoted there by MI, that the internal Lehman 2007 risk analysis report of Shilpickandula and Gorodetsky singled out as being at risk. As of December 2007, it was estimated that the monoline insurers – 11 monoline insurers, all based in New York and regulated by that state's insurance regulator – had given their insurance guarantee to enable the triple A rated securitization of over \$2.4 trillion worth of asset-backed securities. On the official website of the monoline trade association, The Association of Financial Guaranty Insurers, it states that a security insured by an AFGI member has the 'unconditional and irrevocable guarantee that interest and principal will be paid on time and in full in the event of a default': www.afgi.org/who-fact.htm. See Acharya et al. (2009) for more on how inadequacies of insurance regulation in the USA contributed to the 2008 financial crisis.
14. See the Report of the Examiner in the bankruptcy proceedings of Lehman. <http://lehmanreport.jenner.com/VOLUME%203.pdf>.
15. The main role played by relaxed lending seems to have been that the large volume of subprime mortgages originated with little or no money down created a pool of homeowners who quickly were underwater once the upward trend in home prices had turned. Their defaults then contributed to further home price declines. See Mian and Sufi (2008, 2009) and Calabria (2011) for more on this. And by 2007 and 2008, more than half the foreclosures in Massachusetts involved prime loans to homeowners whose homes had mortgages that were larger than the market values of their homes (Gerardi et al., 2007).
16. Note that these are different from the credit rating companies for securities.
17. This includes CDO backed by emerging market bonds, investment-grade bonds, and high-yield bonds, all of which did significantly better. See Newman et al. (2008).
18. [http://fcic-static.law.stanford.edu/cdn_media/fcic-docs/2007-01-00%20Moody's%20Structured%20Finance%20Rating%20Transitions%20-%201983-2006%20\(Moody's%20Special%20Comment\).pdf](http://fcic-static.law.stanford.edu/cdn_media/fcic-docs/2007-01-00%20Moody's%20Structured%20Finance%20Rating%20Transitions%20-%201983-2006%20(Moody's%20Special%20Comment).pdf).
19. See, for example, Madigan (2008).
20. <http://www.nytimes.com/2008/03/17/business/17bear.html>.
21. <http://www.bloomberg.com/news/2011-03-31/morgan-stanley-got-6-9-billion-from-fed-window-in-october-2008.html>.
22. In an EU context, Poghosyan and Čihák (2009) also find that wholesale financing reliance distinguishes vulnerable banks from sound banks.
23. Also, as a result of the financial crisis, 25 US commercial banks became insolvent and were taken over by the FDIC in 2008, including Washington Mutual. A total of 140 more failed in 2009, and 157 failed in 2010. Those bank failures seriously depleted the FDIC funds.
24. For example, in the Greek debt crisis, the story behind the headlines is that, in 2001, Goldman Sachs helped the Greek government borrow billions, with this showing on the government books as a currency trade rather than as debt. That deal gave Greece cash upfront in return for pledging future landing fees for the country's airports. This and

subsequent other deals of a similar nature initially duped the regulators of the European Monetary Union (EMU) into agreeing that Greece met the standards for admission to the EMU (Mitsopoulos and Pelagidis, 2011). Most Greek voters were probably unaware of how their government services were being paid for.

REFERENCES

- Acharya, Viral V., John Biggs, Matthew Richardson and Stephen Ryan (2009), 'On the financial regulation of insurance companies', NYU Stern School of Business. <http://w4.stern.nyu.edu/salomon/docs/whitepaper.pdf>.
- Bartlett, Robert P. III (2010), 'Inefficiencies in the information thicket: a case study of derivative disclosures during the financial crisis', http://www.law.illinois.edu/_shared/pdfs/Inefficiencies%20in%20the%20Information%20Thicket_0926.pdf.
- Benmelech, E. and J. Dlugosz (2009), 'The alchemy of CDO credit ratings', *Journal of Monetary Economics*, **56**, 617–34.
- Bordo, M.D., A. Redish and H. Rockoff (2010), 'Why didn't Canada have a banking crisis in 2008 (or in 1930, or 1907, or 1893)?', paper prepared for the Economic History Association (EHA) conference, Evanston, September, <http://www.eh.net/eha/system/files/Bordo.pdf>.
- Brueckner, Jan K., Paul S. Calem and Leonard I. Nakamura (2012), 'Subprime mortgages and the housing bubble', *Journal of Urban Economics*, **71**, 230–43.
- Calabria, M. (2011), 'Fannie, Freddie, and the subprime mortgage market', Report No. 120, 7 March, Cato Institute.
- Date, Raj and Michael Konczal (2010), 'Out of the shadows: creating a 21st century Glass Steagall', in Johnson and Payne (2010), 61–72.
- European Commission (2010), 'Competitiveness and Innovation Framework Programme (CIP)', http://ec.europa.eu/cip/eip/innovation/index_en.htm.
- European Commission (2011a), 'Innovation Union Competitiveness report 2011', http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/executive_summary.pdf#view=fit&pagemode=none.
- European Commission (2011b), 'Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions', COM(2011) 849 final, http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2011/state_of_the_innovation_union_2011_en.pdf#view=fit&pagemode=none.
- European Commission (2011c), 'Innovation Union Competitiveness report 2011: executive summary', http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/executive_summary.pdf#view=fit&pagemode=none.
- European Commission (2011d), 'Europe 2020: economic governance', http://ec.europa.eu/europe2020/priorities/economic-governance/index_en.htm.
- European Commission (2011e), 'Annual growth survey: Annex 2 – macro-economic report', COM(2011) 11 final, http://ec.europa.eu/europe2020/pdf/2_en_annexe_part1.pdf.
- Fuest, Clemens, Thomas Hemmelgarn and Fred Ramb (2007), 'How would the introduction of an EU-wide formula apportionment affect the distribution and size of the corporate tax base? An analysis based on German multinationals', *International Tax and Public Finance*, **14**(5), 605–26.

- Geanakoplos, John (2010), 'The leverage cycle', in D. Acemoglu, K. Rogoff and M. Woodford (eds), *NBER Macroeconomic Annual 2009*, vol. 24, Chicago, IL: University of Chicago Press, pp. 1–65.
- Gerardi, Kristopher, Adam Hale Shapiro and Paul S. Willen (2007), 'Subprime outcomes: risky mortgages, homeownership experiences and foreclosures', Federal Reserve Bank of Boston Working Paper 07-15.
- Greenberger, M. (2010), 'Out of the black hole: regulatory reform of the over-the-counter derivatives market', in R. Johnson and E. Payne (2010), 99–115. <http://www.rooseveltinstitute.org/sites/all/files/OTC%20Derivatives.pdf>. See also <http://www.rooseveltinstitute.org/policy-and-ideas/ideas-database/out-black-hole-regulatory-reform-over-counter-derivatives-market>.
- Greenberger, Michael (2011), 'Overwhelming a financial regulatory black hole with legislative sunlight', *Journal of Business and Technology Law*, 6(1), 127.
- Hines, James R., Jr (2005), 'Do tax havens flourish?', in James M. Poterba (ed.), *Tax Policy and the Economy* 19, Cambridge, MA: MIT Press, pp. 65–99.
- Huang, R. and L. Ratnovski (2011), 'The dark side of bank wholesale funding', *Journal of Financial Intermediation*, 20(2), 248–63.
- Johnson, R. and E. Payne (2010), *Make Markets Be Markets*, <http://www.rooseveltinstitute.org/sites/all/files/MMBM%20FINAL%20March%208.pdf>.
- Kindleberger, C.P. (1993), *A Financial History of Western Europe*, 2nd edn, Oxford: Oxford University Press.
- Kindleberger, Charles P. and Robert Z. Aliber (2005), *Manias, Panics, and Crashes: A History of Financial Crises*, 5th edn, New York: John Wiley & Sons.
- Leblond, P. (2011), 'A Canadian perspective on the EU's financial architecture and the crisis', in K. Hübner (ed.), *Europe, Canada and the Comprehensive Economic Partnership*, London: Routledge, pp. 165–79.
- Lipsey, Robert E. (2010), 'Measuring the location of production in a world of intangible productive assets, FDI and intrafirm trade', *Review of Income and Wealth*, 56(s1), S99–110, <http://onlinelibrary.wiley.com/doi/10.1111/j.1475-4991.2010.00385.x/abstract>.
- Madigan, Peter (2008), 'JP Morgan CDS exposure may top \$10trn notional', *Risk magazine*, 1 April, <http://www.risk.net/risk-magazine/news/1506245/jp-morgan-cds-exposure-usd10trn-notional>.
- Mian, A. and A. Sufi (2008), 'The consequences of mortgage credit expansion: evidence from the U.S. mortgage default crisis', Working Paper.
- Mian, A. and A. Sufi (2009), 'House prices, home equity-based borrowing, and the U.S. household leverage crisis', Working Paper.
- Mitsopoulos, M. and T. Pelagidis (2011), *Understanding the Crisis in Greece: From Boom to Bust*, Basingstoke: Palgrave Macmillan.
- Mora, Nada (2010), 'Can banks provide liquidity in a financial crisis?', Report, Federal Reserve Bank of Kansas City, <http://www.kc.frb.org/publicat/econrev/pdf/10q3Mora.pdf>.
- Nakamura, Leonard (2011), 'Durable financial regulation: monitoring financial instruments as counterpart to the regulation of financial institutions', NBER Working Paper 17006, May.
- Newman, Daniel, Frank J. Fabozzi, Douglas J. Lucas and Laurie S. Goodman (2008), 'Empirical evidence on CDO performance', *Journal of Fixed Income*, 18(2), 32–40.
- Partnoy, Frank and Lynn E. Turner (2010), 'Bring transparency to off-balance sheet accounting', in Johnson and Payne (2010), 85–98.

- Poghosyan, Tigran and Martin Čihák (2009), 'Distress in European banks: an analysis based on a new data set', IMF Working Paper WP/09/9.
- Pozsar, Zoltan, Tobias Adrian, Adam Ashcraft and Hayley Boesky (2010), 'Shadow banking', Staff Report No. 458, Federal Reserve Bank of New York, July, http://www.newyorkfed.org/research/staff_reports/sr458.pdf.
- Ratnovski, L. and R. Huang (2009), 'Why are Canadian banks more resilient?', IMF Working Paper 09/152.
- Shilpiekandula, Vikas and Olga Gorodetski (2007), 'Who owns residential credit risk?', Lehman Brothers, Fixed Income Research, US Securitized Products Research, 7 September.
- Witt, Gary (2010), 'Statement of Gary Witt, Former Managing Director, Moody's Investors Service, submitted by request to the Financial Crisis Inquiry Commission', 2 June, http://fcic-static.law.stanford.edu/cdn_media/fcic-testimony/2010-0602-Witt.pdf.
- Woodward, Susan and Robert Hall (2009), 'What to do about Fannie Mae and Freddie Mac', <http://woodwardhall.wordpress.com/2009/01/28/what-to-do-about-fannie-mae-and-freddie-mac/>.

PART II

National and Regional Systems of Innovation

4. The European national and regional systems of innovation

George M. Korres

1. INTRODUCTION

Innovation has been recognized as a major source of competitiveness of firms and regions. It is recognized as highly relevant to economic performance and sustainability and thus it has been gaining increased support and attention. Public policies in new technologies aim exactly to reinforce technological capabilities in order to enhance productivity, competitiveness and economic growth. Public support is usually given in the form of ‘direct and indirect measures’, namely grants, loans, tax concessions and equity capital. Regional differences remain the prime source of competitive advantage. A long-term approach to development of regional knowledge economies must therefore combine local (regional) bottom-up approaches with global or European top-down approaches.

This chapter attempts to examine the structure and role of national and regional systems of innovation and their implications for sustainable development and integration and convergence in the EU.

2. NATIONAL AND REGIONAL SYSTEMS OF INNOVATION

The interaction between technological innovation, social learning and economic development is crucial for the survival and growth of the systems of innovation, at national or regional level. Technological policies aim to support and promote the new technologies through different ‘direct and indirect measures’. ‘Direct measures’ usually include different subsidies, or different favourable tax treatments for research and technological activities. ‘Indirect measures’ are carried out in the pursuit of other policy objectives (e.g. competition policy, monetary, fiscal policies etc.), and, consequently, affect different research and technological activities. The interactive model demonstrates the main interconnections between three

systems: society, technology and economy (Mahdjoubi, 1998). Innovation, as a socio-technical comprises system, two main divisions (Korres, 2012):

- Social innovation (social structures, human resource development).
- Technological innovation (technical development).

These two structures foster the development process.

Freeman and the 'Aalborg version' of the national innovation system approach (Freeman, 1987; Freeman and Lundvall, 1988) aim at understanding 'the innovation system in the broad sense'. The definition of 'innovation' is broader. Innovation is seen as a continuous cumulative process involving not only radical and incremental innovation but also the diffusion, absorption and use of innovation and a wider set of sources of innovation is taken into account. In this respect, innovation is seen as reflecting, besides science and R&D, interactive learning taking place in connection with ongoing activities in procurement, production and sales. A wide definition of innovation should be used, including product innovations (both material goods and intangible services) as well as process innovations (both technological and organizational ones).

While there are competing conceptions regarding what constitutes the core elements of an innovation system, it might still be useful to see what the different definitions have in common.

- One common characteristic is the assumption that national systems differ in terms of specialization in production, trade and knowledge (Archibugi and Pianta, 1992). The focus is on the co-evolution between what countries do and what people and firms in these countries know how to do well. This implies that both the production structure and the knowledge structure will change only slowly and that such change involves learning as well as structural change.
- A common assumption behind the innovation system perspective is that knowledge is something more than information and includes tacit elements (Polanyi, 1966). Important elements of knowledge are embodied in the minds and bodies of agents, in routines of firms and not least in relationships between people and organizations (Dosi, 1999).
- Another feature of the idea of innovation systems is a focus on interactions and relationships. The relationships may be seen as carriers of knowledge and interaction as processes where new knowledge is produced and learnt (Johnson, 1992; Edquist and Johnson, 1997).
- A final common assumption behind the different approaches to innovation systems is that elements of knowledge important for

economic performance are localized and not easily moved from one place to another.

We can use the term ‘innovation’ rather broadly in order to include processes through which firms master and practise product designs and manufacturing processes that are new to them. The term indicates a set of institutions whose interactions determine innovative performance. The term ‘system’ refers to a set of institutional actors who play a major role in influencing the innovative performance. We use the term ‘national systems of innovation’ to indicate policies that are related to research and technological activities planning (from both a macro- and microeconomic view) in a country (Korres, 2012).

Systems of innovation may be delimited in different ways; spatially/geographically or sectorally, accordingly to the breadth of activities they consider.

- Geographically defined innovation systems may be local, regional, national or supranational. This type of delimitation presumes that the area in question has a reasonable degree of ‘coherence’ or ‘inward orientation’ with regard to innovation processes.
- Sectorally delimited systems of innovation include only a part of a regional, national or international system. They are limited to specific technological fields (generic technologies) or product areas. They can be, but are not necessarily, restricted to one sector of production. Both ‘technological systems’ (Carlsson and Stankiewicz, 1995) and ‘sectoral innovation systems’ (Breschi and Malerba, 1997) belong to this category. Whether a system of innovation should be spatially or sectorally delimited – or both – depends on the object of study.

The system of innovation approach is also associated with problems and weaknesses. One example is the term ‘institution’, which is used in different senses by different authors – some refer to social norms, such as trust, while others refer to types of organizations, such as universities.

Another important point is that there is no agreement among scholars regarding what should be included in and what should be excluded from a ‘system of innovation’. It should also be pointed out that ‘systems of innovation’ is not a formal theory, in the sense of providing propositions regarding established and stable relations between well-defined quantitative variables. According to the World Bank (2002, p. 8), institutions have three main objectives: they channel information about market conditions, goods and participants; they define and enforce property rights and

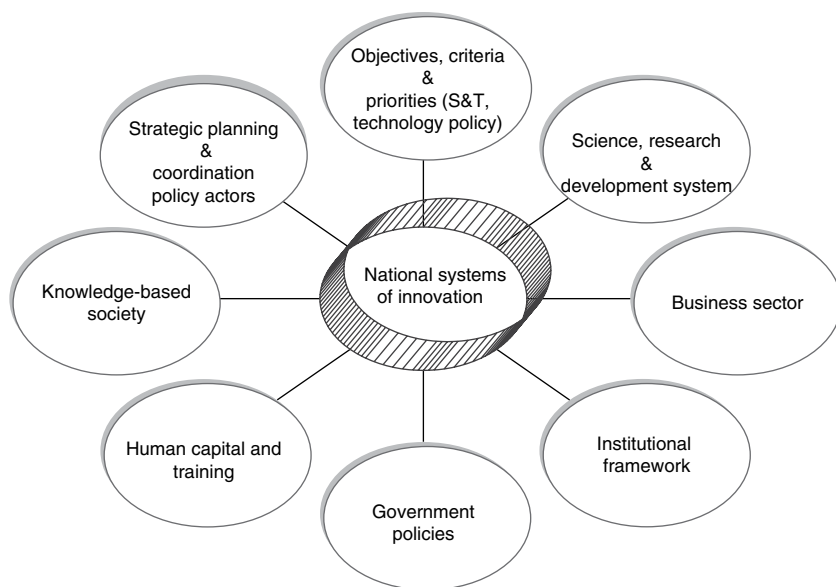


Figure 4.1 National systems of innovation (NSI)

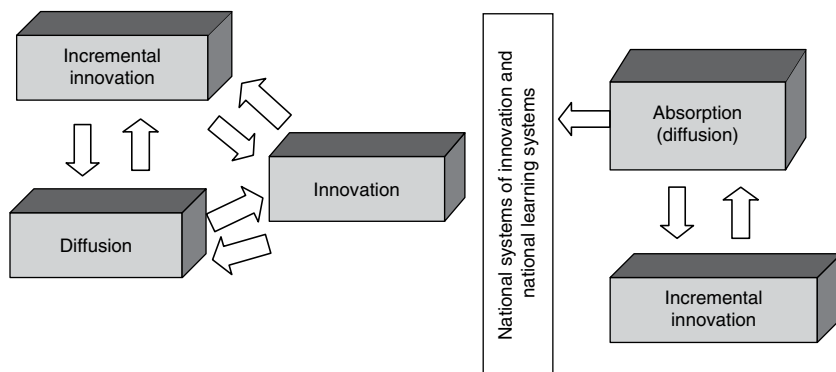


Figure 4.2 National systems of technical change

contracts; and they regulate competition. The overall structure of the functionality of national systems of innovation (NSI) is shown in Figure 4.1.

Figure 4.2 illustrates national and regional systems of innovation and technical change. Regions are considered to play a crucial role in the European Research Area, because they bring policy measures close to the citizen, thereby following the subsidiarity principle, and because they

bridge the EU level and the local level (CEC, 2001). Regions can differ substantially with respect to their industrial specialization, their connections at the national and global level and, in particular, with respect to their potential to face national and global competition. Therefore policy measures are best adapted to the region at hand. It makes sense to regionalize innovation policy for the following four reasons (Korres, 2012):

- Innovation processes take place unevenly in geographic space.
- Innovation networks function differently in various regions.
- Innovation activity is crucial for economic development and growth on the regional as well as on the national level.
- Using various policy approaches in different regions enables countries to gain much more varied experiences, thereby enabling regions to learn from one another.

Recently, academics and policy makers have begun to refine the idea of national innovation systems, considering the utility of 'regional innovation systems' as both a theoretical concept and a policy objective (Cooke et al., 1997). Whilst the regional innovation systems perspective is clearly a development of the innovation systems literature, it can also be considered part of the 'new regionalism'.

The concept of regional innovation systems has been gaining much attention from policy makers and academic researchers since the early 1990s. The approach has been seen as a promising analytical framework for advancing our understanding of the innovation process in the regional economy (Asheim et al., 2003; Cooke and Memedovic, 2002). The popularity of the concept of regional innovation systems is closely related to the emergence of regionally identifiable nodes or clusters of industrial activity as well as the surge in regional innovation policies where the region is deemed as the most appropriate scale at which to sustain innovation-based learning economies (Asheim and Isaksen, 1997).

Most of the new contributions in regional economics are clearly indebted to the pioneering works and intuitions of Marshall, who stressed the importance of local externalities in favoring the geographical concentration of economic and innovative activities. 'Regional innovation systems' has no commonly accepted definition, but is usually understood as a set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge (Doloreux, 2003). The basic argument is that this set of actors produces pervasive and systemic effects that encourage firms within the region to develop specific forms of capital derived

from social relations, norms, values and interaction within the community in order to reinforce regional innovative capability and competitiveness (Gertler et al., 2000).

As Asheim and Gertler (2005) point out, regional innovation systems are not sufficient on their own to remain competitive in a globalized economy and production systems seem to be rather important to innovation systems at the regional level. Moreover, as these authors assent, local firms must also have access to national and supranational innovation systems, as well as to corporate innovation systems. This line of reasoning is followed to a point where the regional innovation system expands beyond its own boundaries through a process of economic integration and globalization.

Many elements characterizing a national system could be, in principle, transferred to a smaller territorial scale and used also to define the regional system of innovation, including Korres (2012):

- the internal organization of firms
- interfirm relationships
- role of the public sector and public policy
- institutional set-up of the financial sector
- R&D intensity and organization
- institutional framework, for instance regional governance structure, political, legal, fiscal, financial and educational arrangements etc.
- production system (including the competition and collaboration faced by firms, market structure, the division of labor and sectoral specialization)
- degree of openness and the capacity to attract the external resources and core hierarchical forces taking into account the peculiarities of different geographical scale.

Many studies of regional innovation systems are motivated by the relation between technical advances and regional growth, depending on the amount of technological knowledge in a region. The concept of regional systems of innovation (RSI) is distinctly different from that of national systems of innovation (NSI). A schematic illustration of the structuring of RSIs is shown in Figure 4.3, which distinguishes between the two subsystems that constitute the main building blocks of RSIs. These are the knowledge application and exploitation subsystem and the knowledge generation and diffusion subsystem. (The main external influences on RSIs take the form of NSI institutions and policy instruments, other RSIs, and international institutions and policy instruments.)

The first subsystem consists mainly, but not exclusively, of industrial companies, while the second comprises various (mostly public sector)

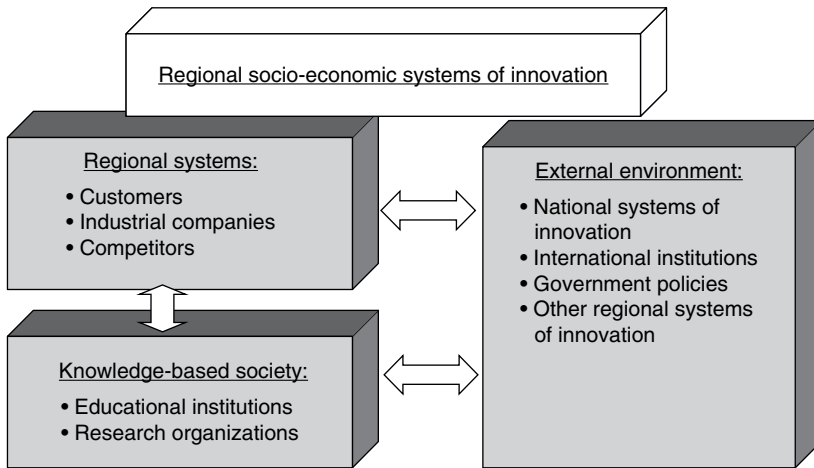


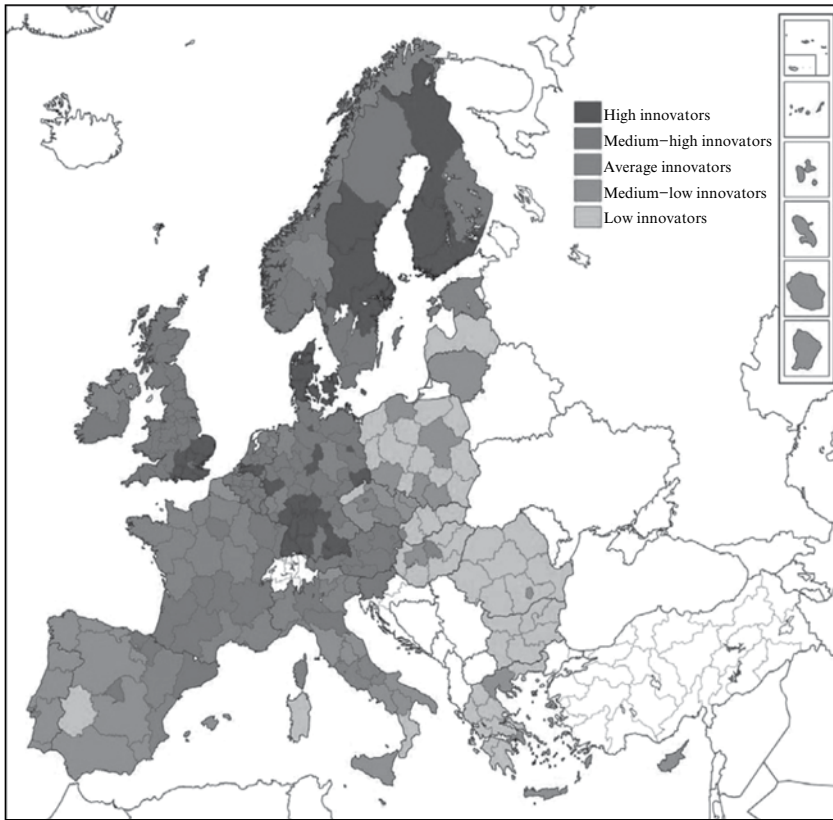
Figure 4.3 The structuring of regional systems of innovation

institutions involved in knowledge creation and diffusion. The distinction between these two subsystems largely corresponds to the division between public and private sectors and between non-commercial and commercial activities.

3. THE EUROPEAN REGIONAL SYSTEMS OF INNOVATION

The EU is one of the most prosperous economic areas in the world but the disparities between its member states are striking, especially if we look at the EU's 250 regions. To assess these disparities, we must first measure and compare the levels of wealth generated by each country, as determined by gross domestic product (GDP). For instance, in Greece, Portugal and Spain, average per capita GDP is only 80 percent of the Community average. Luxembourg exceeds this average by over 60 percentage points. The ten most dynamic regions in the EU have a GDP almost three times higher than the ten least developed regions. Figure 4.4 illustrates the European regional innovation performance groups. We can summarize some of the main results (INNO-Metrics, 2009):

- There is considerable diversity in regional innovation performance. The results show that all countries have regions at different levels of performance. The most heterogeneous countries are Spain, Italy



Source: European Commission (2010).

Figure 4.4 European regional innovation performance groups

and the Czech Republic, where innovation performance varies from low to medium-high.

- The most innovative regions are typically in the most innovative countries. North Brabant in the Netherlands is a highly innovative region located in an innovation follower country. Prague (Czech Republic), Basque Country, Navarre, Madrid and Catalonia in Spain, Lombardy and Emilia-Romagna in Italy, Oslo and Akershus, Agder and Rogaland, and Western Norway are all medium to highly innovating regions from moderate innovators. The capital region in Romania, Bucharest–Ilfov, is a medium–low innovating region in a catching-up country.

- Regions have different strengths and weaknesses. There are no straightforward relationships between the level of performance and relative strengths; many of the 'low innovators' have relative weaknesses in the dimension of innovation enablers, including human resources.
- Regional performance appears relatively stable since 2004. Most of the changes are positive and relate to Catalonia, Valencia, the Balearic Islands and Ceuta (Spain), Paris Basin, East and South-west France, Lower Franconia (Germany), Közép- Dunántúl (Hungary), the Algarve (Portugal) and Hedmark and Oppland (Norway).
- In terms of scientific publications, Europe's strong growth seems to have halted. Actual numbers are still rising, but the EU share of world publications is declining, whereas the US share is recovering.
- Regarding per capita shares, the EU generates fewer patents with high economic value than the USA or Japan.
- The EU is lagging behind the USA in its share of patents in biotechnology and information and communications technology.
- There has been a slight increase in the EU share of global exports of high-tech products in value terms between 1996 and 2001. Japan's share fell sharply in 2001, hit by falling sales of electronic goods.
- Since the middle of the 1990s, the EU has stopped catching up with the USA in terms of labor productivity.
- Large disparities persist among EU countries in high-tech manufacturing. Japan outperforms the EU in high-tech manufacturing indicators while the Central European countries perform better than the EU average.
- The production of scientific research and technological know-how increasingly depends on research conducted in other countries. Indicators of cross-border co-authorship of scientific articles and co-invention of patents seek to shed light on this trend.
- Scientific collaboration with advanced countries is generally much more widespread than with smaller ones. Researchers in 160 countries co-authored at least 1 percent of their internationally co-authored papers with US researchers. The UK, France and Germany also play a leading role in international scientific collaboration.
- By the late 1990s, about 6 percent of patents were the result of international collaborative research. Several factors may affect the degree of a country's internationalization in science and technology: size, technological endowment, geographical proximity to regions with high research activity, language, industrial specialization, existence of foreign affiliates and so on.

- Internationalization tends to be higher in smaller European countries. For example, 56 percent of Luxembourg's patents have foreign co-inventors compared with 30 percent of Iceland's and Belgium's. International cooperation in science and technology is also relatively high in Poland, the Czech Republic and the Slovak Republic.
- International collaboration in patenting is lower in the EU than in the USA. In Japan, international cooperation in science and technology is rather limited.

'Europe Strategy 2020' is a ten-year growth strategy proposed by the European Commission in March 2010 for reviving the economy of the EU to become a smart, sustainable and inclusive economy.

The EU identifies three key drivers for growth, to be implemented through concrete actions at EU and national levels (Korres, 2012):

- smart growth (fostering knowledge, innovation, education and digital society);
- sustainable growth (making production more resource efficient while boosting competitiveness); and
- inclusive growth (raising participation in the labor market, the acquisition of skills and the fight against poverty).

Table 4.1 illustrates the objectives of the European regional innovation strategy for the period 2010–13. The EU strategy towards regional innovation policy emphasizes the following points:

- enhance the scientific and innovation framework and the related structural changes;
- encourage and expand the creation and growth of innovative enterprises; and
- improve the key interfaces in the innovation system.

The main objectives of technological policy may be summarized under five headings:

- improve the efficiency of the transfer of technology from foreign suppliers to local users;
- increase the efficiency of operation of technology;
- strengthen the industrial base;
- develop the indigenous technological capability; and
- smooth adjustment forced by new technologies.

Table 4.1 Objectives of the European regional innovation strategy, 2010–13

General objective: increase of innovation and competitiveness of the regions		
Pillars		
I	II	III
Economy based on knowledge	Innovation culture	Innovative management
<i>Objective:</i> Transition of the regions into the region based on knowledge and the center for innovation	<i>Objective:</i> Improvement of intangible environment supporting innovations (culture, attitudes, norms and behavior patterns, human capital) and the increase of the susceptibility of local authorities and society to innovations	<i>Objective:</i> Higher efficiency and innovativeness in the development process support
Priorities		
● Increased financial support, especially from the state, on R&D ● Enhancing regional R&D potential and the effectiveness of the R&D institutions ● Support to development of high technology industries ● Transition of traditional industries into the more scientific-based ● Development of information society and knowledge-based economy services	● Promotion of innovation and entrepreneurship ● Education for innovation	● Durable partnership ● Anticipating the future ● Effective mechanisms of implementation

Source: ec.europa.eu/regional_policy/conferences/od2006/doc.

In addition, science and research policies should be oriented towards two main objectives:

- to assess the possibilities and needs of private and public enterprises with respect to research and technological activities;
- to choose those priority objectives that can delineate government technological action.

Small countries are likely to need a more comprehensive and targeted policy of cooperative innovative effort in order to develop their future capabilities and make the necessary choices for technological priorities. The participation of member states in the EU research and technological programmes can increase the opportunities for promotion and improvement of research activities, creation of new research institutions so as to support innovation and diffusion of new technologies and, therefore, to improve the level of economic and regional growth and induce social development.

4. CONCLUSIONS

New technologies imply some direct and indirect effects or, more specifically, some micro effects (such as firms or organizations) and macro effects (such as inter- and intra-industrial and regional effects) for the whole economy. New technologies play an important role in sectoral productivity, overall growth, employment, modernization, industrialization, socio-economic infrastructure and competitiveness of a country.

The Community's research programmes also attempt to establish cooperation between theoretical research through the different research bodies of the public sector (such as research institutes and universities) and industrial research through private enterprises.

We can summarize the main conclusions and policy implications as follows: technology policy has been heavily concerned with the external gap of the EU *vis-à-vis* Japan and the USA. However, the same size of gap also exists among EU countries. It is true that technological competition among Japan, the USA and the EU is intense. Moreover, one tends to find most of the European countries in a position of catching up from relatively low levels of S&T output. Although there are some noticeable encouraging tendencies in several European countries, one can expect that with the enlargement of the EU the 'European paradox' will be, at least temporarily, further accentuated. In other words, in relation to its enlarged population, the EU-27's strong performance in science will

contrast increasingly with its weaker development and commercialization of technology.

REFERENCES

- Archibugi, D. and Pianta, M. (1992), *The Technological Specialization of Advanced Countries*, Dordrecht: Kluwer Academic Publishers.
- Asheim, B.T. and Gertler, M. (2005), 'The geography of innovation: regional innovation systems', in J. Fagerberg, D. Mowery and R. Nelson (eds), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, pp. 291–317.
- Asheim, B.T. and Isaksen, A. (1997), 'Regional innovation systems: the integration of local "sticky" and global "ubiquitous" knowledge', *Journal of Technology Transfer*, 27(1), 77–86.
- Asheim, B., Isaksen, A., Nauwelaers, C. and Tödtling, F. (2003) *Regional Innovation Policy for Small–Medium Enterprises*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
- Breschi, S. and Malerba, F. (1997), 'Sectoral innovation systems—technological regimes, Schumpeterian dynamics and spatial boundaries', in C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organizations*, London: Pinter Publishers/Cassell Academic, pp. 130–56.
- Carlsson, B. and Stankiewicz, R. (1995), 'On the nature, function and composition of technological systems', in B. Carlsson (ed.), *Technological Systems and Economic Performance. The Case of Factory Automation*, Dordrecht: Kluwer, pp. 21–56.
- Commission of the European Communities (CEC) (2001), 'The regional dimension of the European research area', mimeo: Commission of the European Communities, Brussels, October.
- Cooke, P. and Memedovic, O. (2002), *Strategies for Regional Innovation Systems: Learning Transfer and Applications*, Vienna, Austria: United Nations Industrial Development Organization.
- Cooke, P., Uranga, M.G. and Etzebarria, G. (1997), 'Regional innovation systems: institutional and organizational dimensions', *Research Policy*, 26(4/5), 475–91.
- Doloreux, D. (2003), 'Regional innovation systems in the periphery: the case of Québec (Canada)', *International Journal of Innovation Management*, 7(1), 67–94.
- Dosi, G. (1999), 'Some notes on national systems of innovation and production, and their implications for economic analysis', in Daniele Archibugi, Jeremy Howells and Jonathan Michie (eds), *Innovation Policy in a Global Economy*, Cambridge: Cambridge University Press, pp. 35–48.
- Edquist, C. and Johnson, B. (1997), 'Institutions and organizations in systems of innovation', in C. Edquist (ed.) *Systems of Innovation: Technologies, Institutions and Organizations*, London: Pinter Publishers/Cassell Academic, pp. 41–63.
- European Commission (2010), *European Innovation Scoreboard 2009: Comparative Analysis of innovation Performance*, Brussels: CEC.
- Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, London: Pinter Publishers.
- Freeman, C. and Lundvall, B.-Å. (eds) (1988), *Small Countries Facing the Technological Revolution*, London: Pinter Publishers.

- Gertler, M., Wolfe, D. and Garkut, D. (2000), 'No place like home? The embeddedness of innovation in a regional economy', *Review of International Political Economy*, 7(4), 688–718.
- INNO-Metrics (2009), *Regional Innovation Scoreboard*, Hugo Hollanders (MERIT), Stefano Taranto la and Alexander Loschky (JRC).
- Johnson, B. (1992), 'Institutional learning', in Bengt-Åke Lundvall (ed.), *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers, pp. 23–46.
- Korres, G.M. (2012), *Handbook of Innovation Economics*, New York: Nova Publishers.
- Mahdjoubi, D. (1998), 'Mapping the regional innovation systems', Working Paper, University of Austin, TX.
- Monfort, P. (2009), 'Regional convergence, growth and interpersonal inequalities across EU', Working Paper, Directorate General Regional Policy European Commission.
- Polanyi, M. (1966), *The Tacit Dimension*, London: Routledge & Kegan Paul.
- World Bank (2002), *World Development Report 2002: Building Institutions for Markets*, New York: Oxford University Press.

5. European innovation policies from RIS to smart specialization: a policy assemblage perspective

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1. INTRODUCTION

Policy initiatives such as regional innovation strategies are strategically and selectively infused by rationales and imaginaries that resonate with major political and societal shifts. A core example is how the transition from spatial Keynesianism to neoliberal thinking has been accompanied by a discourse of the ‘knowledge-based economy’, overpowering the more socially oriented notion of the ‘information society’. Using the notion of policy assemblage, this chapter advocates a more complex and political reading of the role of rationales and imaginaries. Undertaking an analysis of four decades of regional innovation policy in Europe, we show how a variety of concerns, notably around competitiveness, sustainability and cohesion, have all made their inroads into the substantiation and legitimization of innovation policies. In doing so, we pay attention to the way innovation policies have been shaped by the continuous (re)imagination of European, national and regional spaces in terms of developmental ambitions.

The last four decades have witnessed the rise, peak and modification of regional innovation policy. This is especially noteworthy in Europe, where the EU has taken a leading role in the development and proliferation of innovation-oriented policy ideas and practices. The evolution of EU regional innovation policy has been marked by a number of major trends and shifts. Underlying development perspectives have moved from Keynesian to neoliberal approaches; policy perspectives took on board academic notions of learning and the building of institutional capacity; in terms of governance, a direct nexus was created between the EU and the regional level.

This chapter will discuss this process of evolution by applying a policy assemblage perspective. The concept of assemblage draws on French

post-structural thinking (Anderson and Harrison, 2010; McFarlane, 2009), and has recently been interpreted from a more realist stance by DeLanda (2006). A key point in assemblage theory is that, as a whole, assemblages have capacities that are more than the sum of the capacities of their components. In turn, in becoming part of an assemblage, the components – resources, agents, ideas and so on – retain a spectrum of potentialities and capacities that transcend their specific role in the assemblage. In other words, they continue to present an (often unexpected) source of development as well as change. In assemblage theory, social phenomena do not fall into place according to some predestined design or principle, but they result from hard work invested in producing a more or less coherent whole.

The assemblage perspective is particularly helpful in accounting for the performativity of core concepts and ideas, as well as for shedding light on the complexities of creating effective and legitimate forms of policy practice. Policies consist, on the one hand, of tangible components, that is, concrete measures, budget and resources, domains, rules and procedures, demarcated times and places of action and so on. On the other hand, policies tend to be infused and justified on the basis of less tangible, more fluid aspects, such as prominent ideas and discourses, images and expectations. By thinking in terms of ‘policy assemblages’ we can observe how policies emerge and become effective through the assembly and aligning of a heterogeneous set of components, of material as well as of expressive kinds. The use of the assemblage perspective allows us also to deal with the ambivalences, frictions and dilemmas stemming from the compound nature of policy making, drawing on notions of policy discourse as well as policy practice. It helps us, moreover, to account for the more technical and political aspects of policy making (Prince, 2010), at different levels.

The chapter is structured as follows. First, a theoretical framework is presented drawing from assemblage theory, notably its distinction between coding and territorialization. Subsequently, a historical account of policy evolution is presented using key documents and evaluations published by EU departments and (funded) organizations dealing with regional innovation policy.

2. POLICY ASSEMBLAGES

This section sets out our basic conceptual framework. To account for the semiotic and practical sides of policy making, and their intertwining, we will start with what are generally considered as two core dimensions of

assemblages: coding and territorialization. Coding, which covers the semi-otic (discursive) aspects of policy making, can be divided into two major policy processes: framing and scripting. Territorialization, in turn, deals with the realm of policy practice. Territorialization serves an important aim in dealing with the multi-level, multi-actor and multi-issue characteristics of policy making. In line with our approach, it should be added that we do not suggest that these concepts represent essential aspects of policy making; they are considered primarily useful analytical tools to study policy dynamics. Above all, their significance is epistemological, not ontological.

Coding

The first dimension, coding, deals with the expressive dimension of assemblage (DeLanda, 2006), more specifically the formative–strategic aspect of policy assemblages (Prince, 2010), that is, the development and adoption of discourses to mark out, characterize and legitimize a particular policy. In coding, an important role is played by key signifiers, and the semantic webs woven between and around them, in the form of ‘chains of significance’. In our case, innovation is associated with the regional level, and also with notions of economic, social and environmental sustainability. These discursive practices result in the development and institutionalization of what Collier and Ong (2005, p. 11) label ‘global forms’, phenomena that ‘have a distinctive capacity for decontextualisation and recontextualisation, abstractability and movement, across diverse social and cultural situations and spheres of life’.

The coding of policy assemblages comprises two major discursive practices: framing and scripting. This division corresponds with Torfing’s observation (2011, p. 1881) that discursive practices ‘are not only *staging* the choice and interaction of the relevant policy actors, but also seem to be *scripting* their actions’. Framing starts with associating a policy with selected key signifiers and their chains of signification, thus relating to the ‘grand’ or meta-stories about societal and economic prospects and development, as well as about what constitutes legitimate and effective policy making. Building on this semantic position, particular policy frames or rationales are developed and invoked that connect specific ‘policy problems’ to specific sets of solutions, where especially the latter are prone to evolve into ‘global forms’. So to address the gap between advantaged and disadvantaged regions, the latter should implement regional innovation and clustering strategies, approaches that have developed and circulated across the globe. Framing also plays an important role in legitimizing a policy by grafting policy rationales onto what are called

‘derived theoretical rationales’ (Laranja et al., 2008). Policies are deemed to be prudent because they are underwritten, and refined, by academic ‘evidence’.

The other face of policy coding is scripting. Scripting assigns particular roles and tasks to policy actors, thus enabling as well as constraining the processes of subject and strategy formation. More specifically, scripting details how the chain of agents and organizations extending from the initiating ‘policy makers’ to the final ‘policy takers’ is organized. How are agents expected to be linked in terms of strategic, programmatic and evaluative activities? How is the interaction with stakeholders envisaged? How do chains of legitimacy and accountability take shape? What role is assigned to different levels of administration? Summarizing, where framing explains the ‘what’ and ‘why’ of policy making – which solution addresses which problem, on the basis of which policy and derived theoretical rationales – scripting details the ‘how’ and ‘who’ – which steps to take and which roles to play by which organization. The latter helps, to quote Shore and Wright (1997, p. 35), to understand ‘how policies work as instruments of governance, as ideological vehicles, and as agents for constructing subjectivities and organizing people within systems of power and authority’.

Territorialization

Now we turn to the second dimension of policy assemblage, territorialization. This concerns practical–organizational aspects of assemblages in material and institutional terms. The crux of territorialization is not so much the aspect of spatial demarcation (although this also plays a certain role), but the setting in place and linking together of all kinds of resources, creating what can be seen considered as a marking and creation of an ‘organizational space’. Territorialization involves the building of actor networks and their stabilization and marking in the wider space of policy making (Latour, 2005). Territorialization entails, in other words, the ‘everyday’ practice of policy making and implementation, involving the creation and bringing together of a variety of organizational–logistical resources and mechanisms. In relation to coding, territorialization thus presents acts of concretizing and contextualization, of overcoming the many hurdles confronted by policies when they are put ‘in practice’.

However, territorialization does not just follow coding. On the contrary, in many cases coding entails the capturing of an emerging, apparently successful, policy practice, turning it into a decontextualized, expressive form (DeLanda, 2006). While certain details of policy making may be premeditated on the basis of abstract thinking, global policy forms

generally originate from concrete practices, in which the latter often come to feature as ‘success stories’. In the case of regional innovation and cluster policies, examples of such ‘success stories’ are Silicon Valley, Baden-Württemberg, Rhône-Alpes, among others. Decontextualization and coding allow frames and scripts to travel and engender policy making elsewhere, thus contributing to the strength and proliferation of a global policy form. What emerges is thus not only a policy form but also a policy geography. The latter consists of policy locales, each manifesting its own forms of coding and territorialization, as well as diffusion channels and relay networks connecting the locales at higher scales.

The geographical dimension, including a notion of scale, greatly adds to the complexity of policy-making processes. The channels of policy transfer present, in terms of Latour (2005), mediators rather than ‘simple’ intermediaries. As mediators they play an important role in modifying global forms and geography of policy making (Legendijk and Cornford, 2000). Such mediators consist of a wide variety of actors, networks and circuits, including leading policy entrepreneurs, gurus, think tanks and policy research centres (Thrift, 1997), and international policy networks, as well as broader social and media networks that support what Thrift and Olds (1996) have aptly labelled the ‘cultural circuit of capital’. These mediators all present assemblages themselves, with different kinds and degrees of territorialization that help ideas, scripts and resources to travel.

What thus emerges, in geographical terms, is a topology of nested assemblages. A basic distinction can be made between two levels. First, policy locales constitute the centres of policy making and implementation, such as regions in the case of regional policy making. Here, policy assemblages serve to put policies into practice, mustering knowledge and resources, building institutional capacities, engaging with stakeholders, and measuring and communicating impact. Second, policy transfer networks and organizations engage in the circulation and mediation of codings – frames and scripts – abstracted from, as well as infusing, policy locales. In turn, the mediation at the policy transfer level is also coded, by providing a language to assess, compare and steer policy practices at the level of locales. This coding contains the understanding of policy making in terms of, for instance, ‘best practices’ or ‘how-to’ manuals of policy implementation (Prince, 2010), learning protocols, funding criteria, calculative techniques such as benchmarking, impact assessments and, through aggregation and interpretation, reviews and foresight. Such understanding is often advanced, moreover, by charismatic experts and successful international consultants. Coding is, in turn, substantiated and justified through the building of chains of signification with core political

ambitions (often masquerading as ‘societal’ ambitions) such as competitiveness, cohesion and sustainability.

Such alignment presents a process of ‘overcoding’, that is, the homogenizing of a population through a common set of empty or floating signifiers (Colebrook, 2002). Overcoding ensures that the frames and scripts articulated at the level of policy locales are brought in line and resonate with prevailing political perspectives and ambitions. How this works will be the topic of the next section.

(Neoliberal) Overcoding

In the orchestration of policy transfer and overcoding, a crucial role is played by ‘central’ agents – state and non-state – and the core discourses adopted, articulated and circulated by them. Such agents include national bodies, as well as international organizations to which certain policy responsibilities have been delegated, such as the EU, the OECD and the World Bank, as well as a wide range of think tanks and influential ‘experts’. While, as explained before, many agents are involved in policy transfer, public bodies play a fundamental role in providing the main institutional infrastructure for mediation and support, as well as the main policy discourses feeding into overcoding. Dominant trends, such as the upsurge of neoliberal thinking, make inroads through the coordinating and controlling activities of the state and other central agents (Cumbers et al., 2003).

In ‘making inroads’, however, overcoding does not imply a simple route from dominant ways of thinking to policy practices. On the contrary, overcoding involves intricate discursive practices, in which policy performances are measured up to certain standards following scripts of monitoring and assessment, and codes of articulation. Such standards correspond to core signifiers – for example innovation, competitiveness, cohesion, sustainability – as well as to prevailing policy conventions, for example on financing, project development and management, accountability and evaluation. In other words, not only does territorialization not just follow coding; coding does not simply follow overcoding. As Prince (2010) and Arts and Lagendijk (2009), among others, claim, one should always take account of the ‘hard’ work of policy making ‘on the ground’, and the impact of the mediators involved in processes of policy transfer, implementation and monitoring. While policy making is globally integrated through ‘neoliberal’ practices of policy transfer and ‘neoliberal’ overcoding, each site will manifest its own form of what Brenner and Theodore (2002) call ‘actually existing neoliberalism’.

In assemblage terms, the way in which policy locales are brought in

line with policy overcodes depends on two factors. First, it depends on how strongly local assemblages have become coded, and can be adapted through (re)coding (which is, in turn, a function of their local territorialization). Second, an important role is played by the territorialization of policy transfer, and its capacity to homogenize local codings through the practical work of overcoding. Neoliberal overcodes have been transferred, in particular, by the imposition of specific modes and techniques of accountability, and the accompanying 'control' versions of legitimacy. Such discursive practices have had a great impact on the territorialization of local policy making, for instance through the use of 'objective' input, throughput and output indicators, resulting in what has been characterized as 'technocratization' (Gertler, 2001). If executed successfully, such technocratization greatly enhances the grip of central agents on policy locales. Yet one cannot consider trends towards homogenization as given or self-evident. They can only result from continuous hard work from the centre as well as from all intermediary agents. To what extent this really materializes is a matter, of empirical fact, not a matter of principle.

By charting the conceptual and practical intricacies of overcoding, both top-down and bottom-up, we can also shed light on the political nature of policy making. A first association is that of the political with politics, which would mean with the expressive (interpretive, strategic) side of assemblages. In his account of policy assemblages, Prince (2010) locates the political largely at the level of the formative-strategic aspects of assemblages, that is the realms of 'coding' and 'overcoding'. Coding is political through the way it selects certain ideas, prioritizes certain forms of action and strategies, draws on certain forms of knowledge, and privileges certain actors while excluding others. Frames and scripts, accordingly, are political entities based on closure.

However, in addition to articulating such choices, the political also manifests itself through terms of reference in which such choices are couched, and the techniques through which they are given organizational and material form. This even applies when these terms and techniques appear to be free from contestation and considered self-evident. As argued by Varró (2010b), any vocabulary always comprises a necessarily political view of how a particular issue, such as regional development, relates to particular general interests (however defined). Consensus and self-evidentiality are not givens, but stem from the fact that political discussions generally do not question universalizing notions of the social. Consensus is reached by silencing possible alternative views, while self-evidentiality is achieved by turning policy and derived theoretical rationales into mantra-like narratives (Hillier, 2000). An example is how, in neoliberal thinking, economic 'imperatives' are invoked to promote the 'learning economy', with

emphasis on place-based innovation and competitiveness. Such localized, supply-side orientations obscure the ways cities and regions may have to meet other ‘imperatives’ – such as the financial crisis through strategies of ‘resilience’ – as well as the fact that other regional responses may be possible (Ward and Jonas, 2004). Hence the terms of reference required for any political debate to take place, for any politics to be territorialized and coded, can never be self-evident. They always present political forms of closure and silencing.

The political significance of ‘technical’ aspects, moreover, goes beyond mere instrumentalization (scripting and territorialization) of codings. Certain ‘technical’ choices, such as the use of particular policy standards or methods, or the enrolment of certain capacities, may be informed by specific political ambitions. Such practices may serve to invest a policy with a particular positionality and identity, and to mark out a specific domain for a policy to cover. In the EU, for instance, the ways legitimacy and accountability are understood and practised have a decisive impact on the shaping of European policies regardless of the policy field. So overcoding is supported here through universalizing repertoires of practice and technologies (van Heur, 2008).

A final point is that, given their discursive nature, forms of overcoding are never complete, and always temporary. Indeed, under the surface of consensual languages and universalizing practices, the meanings of the social, spatial and technical continue to be negotiated and contested, even if only at the very margin. One of the key research challenges, therefore, is to detect the rise of alternative forms of territorialization and alternative codings, and see to what extent they assemble the power and acquire the clout to defy and overturn current overcodes. Another possibility is that new overcodes emerge that provide an alternative reading, and hence meaning, of existing practices. Although the latter may simply be a manifestation of ‘old wine in new bottles’, when such alternative readings gain sufficient appeal they may also provoke a kind of ‘paradigm shift’. Both such cases will be examined for the case of regional innovation policy below.

3. REGIONAL INNOVATION POLICY: EMERGENCE AND CODING

As referred to above, regional innovation policy originates basically from two types of state policies, namely national technology policy and regional (or spatial–economic) policy. In the postwar period, these policies initially evolved as separate fields. This changed when technology policy extended

its scope from 'pure' technology production and circulation to innovation, and when regional policies broadened out from Keynesian redistribution and investment subsidies to business support. One frontier country was France, where these recordings supported the development of a new possible assemblage around the notion of the 'growth pole'. The promotion of state technology development in the periphery (i.e. out of Paris) was combined with a strategy of innovation-oriented business support. Similar initiatives followed in the UK and West Germany (Cooke, 1985). In terms of derived theoretical rationales, an important source of inspiration was the system approach to innovation, as well as the debate on the important seedbed role of SMEs. This was translated in to a 'self-help' policy rationale in which limited resources would serve to boost certain targeted segments of the local economy.

The recoding of the policy form not only affected its substance, but also its institutional and organizational aspects. Zooming in on the performances of local businesses, research institutes and their interaction, the old policy assemblages, with a singular, top-down form of territorialization, became increasingly impractical. Because of regional specificities and complexities, it became clear that detailed national scripts and practices would not work and that innovation policies needed to be shaped at the regional level itself. According to Cooke (1985, p. 259), 'There has to be a regional-level policy development with national government playing coordinative and supportive roles'. This shift downwards started with policy implementation, through providing scope for the practical adaptation of national R&D policies and instruments, focusing on technology development and absorption. Gradually, decentralization also started to cover policy formulation, promoting more decentralized forms of innovation and economic development policy (Ewers and Wettmann, 1980), calling for more 'bespoke' policy approaches (cf. Howells, 2005; Todtling and Trippl, 2005). In addition, the focus on technological innovation was complemented with an interest in management practices, the provision of joint services and sector studies (Bachtler et al., 2003; Molle, 1983). Both the coding and territorialization of innovation policy thus became organized at a regional level, set in a national framework in what can be described as a nested policy assemblage.

The shift to a more 'bottom-up' approach has been justified on the basis of policy rationales supporting collective, strategic forms of regional governance featuring close involvement of the business community. Regional governance should foster public-private collaboration, and invest in a 'soft infrastructure' nurturing networking and trust-building (MacLeod, 2001; IRE, 2008). Rather than the singular focus on large companies, these practices were now targeting other business segments, notably

SMEs. Such regionalized business support and governance modes were underwritten by well-known derived theoretical rationalities combining economic–geographical work on the region (labelled as ‘TIM’ approaches) and insights into cognitive and interactive aspects of innovation (Loasby, 1998; Boschma, 2005).

4. EU REGIONAL INNOVATION POLICY: ASSEMBLAGE OF RIS/RITTS

Next, enter the EU (then called the European Community). The recoding and reterritorialization of innovation policy highly appealed to the Community, specifically to the directorates responsible for regional and industrial development (now known as DG-Regio and DG-Industry). The coding of ‘regional-level policy development’ with a supply-side orientation, with central government ‘playing coordinative and supportive roles’ matched Europe’s neoliberal programme of market integration and supply-side-led growth. More specifically, it addressed a major conundrum faced by the Community. For both economic and political reasons, it was paramount that spatial inequalities across Europe be reduced. But how to accomplish this without weakening economic growth, or, even worse, distorting the operation of the free market? How to accomplish, to use Europe’s own codings, ‘balanced development’? One solution has been to create a highly regimented system of regional policy, geared towards investments in physical infrastructure, notably through overcoding in the form of detailed scripts of resource allocation and usage.

In the case of regional innovation policy, a specific approach was followed. Lured by the ‘self-help’ rationale and the nested model of policy organization, the Community was able to set apart a small chunk of its regional policy budget under a special arrangement (Article 10 of the European Regional Development Fund). This money was used to fund the drafting and, in part, implementation of regional innovation strategies (initially framed as ‘technology plans’). What made this assemblage unique was that it was able to largely bypass, apart from financial–administrative issues, the national level. This allowed the Community to engage in overcoding not only through scripting, but also through framing. The Community thus became a key promoter of framing regions as engines for learning, innovation and ‘place-based’ economic growth. By supporting regions, and thus business environments rather than individual businesses, the approach could be coded and legitimized as market reform. From a more political stance, what counts for the Community is that policies conform to the (neo)liberal idea that intervention is only warranted in two

cases, namely (1) in the case of market failure and (2) when welfare distribution is found wanting (as in the case of spatial inequalities). Place-based forms of nurturing knowledge development and circulation, targeting SMEs, meet both these conditions (PRO INNO, 2009).

In practical terms, DG-Regio and DG-Industry set up a joint programme supporting regional innovation based on Article 10 and the Community's Innovation Programme. In 1993, corresponding to the two directorates involved, two schemes were launched:

1. Regional Technology Plans (RTP), followed by Regional Innovation Strategies (RIS), destined for less favoured regions (ERDF-assisted NUTS-2 areas, later the 'cohesion regions'), and
2. Regional Innovation and Technology Transfer Strategies (RITTS), open to all (kinds of) regions, with explicit focus on innovation support structures (now known as 'competitiveness regions').

Delivering a small amount of seed money (around €0.5 million, with 50 per cent European support), these schemes funded the establishment of regional structures to initiate and try out regional innovation practices. In line with the Community's policy rationale of 'mainstreaming', that is, the idea that any Community-supported project should result in encoded forms of policy making that can be applied more widely, important aspects of the programme were learning and dissemination. Learning was brought about by scripting a requirement for drawing policy lessons in the RIS/RITTS policy manuals (European Commission, 1996). Dissemination was facilitated by the establishment of a variety of platforms and networks dedicated to interregional learning. This included, in particular, the IRE (Innovating Regions in Europe) network and its Mutual Learning Platform (IRE, 2006). IRE has played a pivotal role in diffusing and advocating the 'RIS/RITTS methodology', framing it as a holistic, system-based approach to regional development.

Documentation from the Innovating Regions in Europe network sheds an interesting light on the coding and territorialization of regional innovation policy in the RIS/RITTS era. The key policy rationale is couched in terms of achieving regional 'excellence' by accumulating strategic intelligence (through foresight and benchmarking scripts) and the exchange of 'good' or 'best practices' for regional knowledge creation and valorization (IRE, 2006; EC, 2008). This approach is underwritten by two derived theoretical rationales. First, the notion of the knowledge economy, drawing from theoretical work on the fundamental role of knowledge in the economy (Jessop, 2009), combined with strategic management thinking (accompanied by SWOT scripts) (Lagendijk, 2007). In

theoretical terms, a fundamental issue here is the shift from a relative to an absolute conceptualization of ‘competitiveness’ (cf. Porter, 2000). In an absolute view, regional wealth is not based on the relative disposition of resources and levels of productivity, but on knowledge-based distinctiveness. Second, regional excellence and strategic intelligence are shaped by forms of regional governance grafted on to the notion of the ‘associational economy’ (Cooke and Morgan, 1998). The core claim of the associational economy perspective is that local state, business, educational and support organizations should join forces to develop and implement sector- and innovation-oriented strategies. Such ideas have been elaborated particularly in the context of cluster approaches, featuring cluster mapping, networking strategies, collaborative innovation and institutional capacity-building aiming at (re)orienting a region’s sectoral or ‘cluster’ profile (cf. CLOE, 2007).

In addition to the close links in codings with the academic debate, what has made European regional policy particularly successful is its territorialization. Within the highly complex, politicized, volatile context of the European Community/Union, RIS/RITTS managed to carve out its own organizational space, with its own boundaries. At the Community level, it managed to do this by promoting the political and administrative proliferation of regional and cohesion policies, coupling a ‘strong’ story – innovation, balanced development, self-help – with a small budget and lean organization. As explained, its special position allowed it to largely bypass the national level, so that central coding (like the RIS/RITTS scripts) could be applied directly to the regional level. At the latter level, moreover, territorialization occurred by the setting up of dedicated organizational units engaged in the drafting, submitting and implementing of regional plans. In many cases entire regional governance structures were established to grasp the expanding opportunities offered by European regional policy. Finally, across Europe, a wide range of actors, including politicians at different governance levels, academics, research centres and business representatives jumped on to the bandwagon of regional innovation policy, facilitating the build-up of resources and further infusing and disseminating the concept and practice.

5. EUROPEAN REGIONAL INNOVATION POLICY UNDER CHALLENGE

While successful, the coding and territorialization of RIS has been contested on various fronts. What makes the chains of significance intriguing is how they connect absolute competitiveness – based on producing and

using distinctive knowledge – and collaboration – through the exchange of knowledge. From a broader policy perspective, this raises a critical issue of how policy makers, notably at the local level, are motivated to serve the general interest. To put it bluntly, if regional agents realize that a certain practice proves to be effective, would they then not be tempted to protect this form of knowledge, rather than ‘mainstreaming’ it? IRE and other bodies involved in regional policy have been addressing this issue to some extent, by discussing the role and meaning of knowledge and by discussing and scripting the build-up and exchange of ‘best practice’ (IRE, 2008). More generally, policy makers and students have stressed that there is no magic bullet, that each practice requires local adaptation and implementation and monitoring. Best practice is thus about learning, not copying (IRE, 2006, 2008). In recent debates on the evaluation of regional and cohesion policies, a call has been made for moving away from success stories to learning from both success and failure (Reid, 2008). Yet pregnant questions remain. If achieving distinctiveness in the knowledge economy is so paramount, to what extent can the circulation of ‘best practices’ among regions really make a difference?

Even if ‘best practices’ circulate, the question arises to what extent they can infuse the catching up of laggard regions. According to Oughton et al. (2002), catching up may be inhibited by what they call the ‘innovation paradox’. The policy rationale of ‘self-help’ is based on the idea that subsidies and assistance given to laggard regions will help them to substantially increase their learning and innovation capacities. Yet the extent to which this takes place depends on the region’s absorptive capacity for turning external resources into effective plans, projects and measures. As Oughton et al. (2002) observe, this capacity is often lacking, thus undermining the very idea of ‘self-help’. Moreover, even when basic capacities are present, it takes a long time from building up a local governance structure and ‘soft infrastructure’ to producing world-class excellence and distinctiveness. In general, many regional plans and initiatives pursue the same dreams of becoming the next hot-spot in biotech, ICT or business services. From a political perspective, what is at stake here is the modernist view in which places, although with differences in time, all march along the same path towards an envisaged optimum level of wealth (Massey, 2005).

Another fundamental issue is the understanding of the region. In the 1990s, the coding of regional significance reached such a prominence that it presented a high degree of closure. The result was that in both academic and policy circles, the region became the focal point of the debate. Alternative views thus had to start with challenging the dominance of the region. In line with the competition–collaboration conundrum explained above, this started with refuting the idea that lagging areas and poorer

communities would benefit from an approach pitting regions against each other in their search for ‘excellence’ (Amin and Thrift, 1993). Not only was this model considered flawed from a political stance, it was also criticized for universalizing an exceptional model of spatial–economic development, that of the archetypal Marshallian district or high-tech agglomeration. This prompted a call for considering the ‘non-local’ aspects of regional development, and, in a more sophisticated way, the understanding of the region in ‘relational’ terms. The latter seeks to avoid what Sassen (2006), in her usage of assemblage, calls the ‘endogeneity trap’. Rather than seeing the region as a bounded entity primarily constituted through internal mechanisms, the region is considered as a fragment, with potentially some degree of coherence, in a world in which most entities and processes are organized at other scales and in other settings. On reflection, it may be striking how much hard work the debate has been investing in loosening the regional straitjacket, in view of the widespread evidence for and recognition of other spatialities (Varró, 2010a). In our view, the effort it takes to unlock the debate vindicates the significance of closure and the political nature of understanding spatialities.

The policy side, on the other hand, has manifested similar trends of zooming out and connecting to other scales. An important moment was the EU’s Lisbon Strategy, in which innovation became the core aspiration for a much wider set of EU policies, and which led to three major trends of policy integration. First, cohesion policies and Community programmes such as Interreg had to commit much larger budgets to innovation-oriented programmes (EC, 2006). Second, industrial and regional policies were more intertwined through the elaboration of ‘place-based’ cluster approaches (Barca, 2009). Third, an idea was launched to connect research policy (including the European Research Area) to ‘place-based’ innovation approaches (Soete, 2009). These moves presented a wish to build a stronger alignment of regional policy, industrial policy and research policy, in view of the Lisbon Agenda’s main ambitions to strengthen the Union’s competitiveness and cohesion (Tewdwr-Jones and Morais Mourato, 2005).

6. TOWARDS ‘SMART SPECIALIZATION’

As a result of these various changes, regional innovation policy has turned from a hotchpotch of local projects to an embedding of initiatives in a broader multi-level and multi-sector governance context, with a completely different form of territorialization. Also in response to the eastwards expansion, after 2000 the RIS programme focused on

the accession countries, promoting learning between regions from ‘old’ and ‘new’ member states. A final round of RIS was launched in 2005, and the IRE network shut down in 2008. The learning and knowledge exchange approach was embedded within the new programme of DG-Regio, ‘Regions for Economic Change’ (RfEC) (EC, 2006). By sharing excellence, RfEC seeks to contribute to internal ‘balanced development’ and the Union’s overall competitiveness, in line with the RIS-RITTS programme. Other RIS-RITTS elements, such as the support for networking, have been continued in the context of the PRO INNO innovation policy initiative of DG Enterprise & Industry (PRO INNO, 2009).

Compared with the hard work needed in the academic debate to move away from a regional straitjacket, policy recoding and reterritorialization has occurred more smoothly. This can be attributed to the fact that, as described above, regional innovation policy has always been part of a nested configuration of policy assemblages. As explained above, the relative autonomy that EU regional innovation policy enjoyed in the 1990s was more a matter of territorialization than of coding, more a matter of practice than of principle. Policy rationales such as streamlining (i.e. focusing on the core aims of competitiveness and cohesion) and policy integration (aligning different domains) served to justify a transition to another policy form. A concrete reason for recoding reterritorialization and overhaul of regional and cohesion policy, moreover, was the massive eastwards expansion undertaken in 2000, which radically changed the inequality map of the Union (Bachtler et al., 2003; Bachtler et al., 2007).

In addition to these territorial aspects, recoding has also been accompanied by changing political views on the regional problem. Although the debates on the issues are still ongoing, two developments are particularly noteworthy. The first concerns a move towards a more differentiated view on regional ‘opportunities’. In part inspired by debates on the spatial concentration of core economic activities within major agglomeration and along major axes, a differentiated view starts with an acceptance that only a limited number of regions can be at the frontier of research and innovation. Accordingly, non-core regions need to find alternative routes to position themselves in the knowledge economy. Adopting an evolutionary approach, Foray (2006) and Soete (2009) thus make a case for ‘smart specialization’. Rather than targeting similar clusters or technology segments, regions should explore individually how promising technologies can be applied to views of local capabilities and scope for enduring market potential. Differentiation entails a basic distinction between ‘leading’ regions that primarily engage in the valorization of new, frontier technology, and ‘follower’ regions searching for specific combinations and applications meeting market opportunities. This should be accompanied by an

‘unbounded’ view of the regional economy, taking into account the critical role played by external economic and research linkages, and the position of regions in ‘global’ value chains.

Such ‘unboundedness’ not only bears on the economic but also the governance dimension. A second move concerns the position of the region in spatial governance structures. This debate focuses on the question to what extent one should move from the existing division of responsibilities between spatial levels to a division and alignment of tasks (Soete, 2009). Breaking with the principle of keeping a strict separation of political and administrative responsibilities, as implied by the EU principle of subsidiarity, a task-based model is based on a process of mutual recognition and blending of strengths and opportunities at different levels. If such a flexible model of vertical coordination and collaboration is applied to regional innovation policy, the latter is recoded and reterritorialized in quite fundamental ways. Regions should no longer be considered as generic laboratories producing ‘best practices’ to be mainstreamed to the community at large. Instead, regional innovation practices should become strategically tied to specific (combinatory) research and innovation networks and programmes at (inter)national levels. Smart specialization in research networks and value chains, in other words, should be accompanied by smart specialization in a multi-level governance approach to innovation. Instead of focusing on ‘best practices’, policy should focus on an assessment of missing strategic connections and other development constraints (Soete, 2009).

From an assemblage perspective, such a move will encounter major points of resistance. A first sensitive issue, as already mentioned, is that it will require a decoding of the subsidiarity principle, which presents one of the pillars of the EU’s multi-level governance structure at present. In addition, a more flexible approach will not be easy to match with the neoliberal overcodes ruling much of the EU’s governance practices. As referred to above, EU policies have become more and more dominated by top-down goal-setting, managerial and financial control, project tendering and evaluation. In terms of accountability and legitimacy politics, this reflects neoliberal preferences for limited state intervention, competition-based forms of governance, financial accountability and performance assessment. The result is a procedural, technocratic relationship between programmes at the EU level and projects at the local level. Multi-level governance, in contrast, requires more long-term vision and strategy making at a central level of policy making, and thus calls for a move towards a more programmatic and longer-term policy approach. Moreover, rather than being imposed solely in a top-down way, such a strategy should be articulated and attuned with visionary as well as

practical developments ‘on the ground’ (Howells, 2005). A key question is thus whether ‘smart specialization’ as discussed here can be territorialized under neoliberal overcodes.

7. CONCLUSION

This chapter started from the acknowledgement that policy design and transfer exhibit a complex, evolutionary pattern of development. To come to terms with this complexity, an approach is required that accounts for both the expressive and material–organizational aspects of policy making, as well as for the critical roles of agency and institutional forms. For this purpose, this chapter has adopted the neo-realist approach of assemblage theory. The evolution of European innovation policy over the last four decades has been disentangled and put in context using the notions of (over)coding and territorialization.

Assemblage theory serves to identify core operators in the construction of social phenomena, without resorting to pre-given theoretical concepts. Significantly, it pays attention to how a phenomenon creates its own space and processes of structuration. European regional innovation policy could emerge and proliferate because of the relative autonomy it managed to enjoy in the 1990s, benefiting from and contributing to a booming academic discourse and policy interest. The combination of the latter helped to dramatically raise the significance of the region in innovation and economic growth. It thus generated the capacity to muster considerable support across Europe, and to forge effective networks of exchange. Yet, in terms of both coding and territorialization, the policy encountered major obstacles. In particular, the regional lens on innovation proved too narrow, and changes of and within the EU’s governance structure, as well as political shifts, called for a stronger integration of innovation policies within the broader policy framework of the Union.

The most fundamental change has been a reversal in the roles of innovation and cohesion. In the past, innovation was seen as a tool for boosting regional development and, in particular, the catching up of laggard regions. Now, cohesion, as well as other policies (research policy, industrial policy), are seen as deliverables for the Lisbon Agenda and its follow-up, Europe 2020. In other words, they are the servants of innovation. Policy integration means that, more than ever before, the chain of signification is now pulled by a single force. And that force is the need for innovation. In our vocabulary, policies, programmes and projects need to be overcoded primarily in terms of innovation, with other ambitions

(sustainability, cohesion) coming in second or third position. This has opened the door for a less critical stance towards spatial inequality, for an acceptance of the ‘forces’ of agglomeration and concentration that ‘inevitably’ accompany the rise of centres of global ‘expertise’ and ‘competitiveness’. It is this pivotal issue that drives the current debates on ‘smart specialization’ and the reform of cohesion policy.

Besides this empirical account, the theoretical contribution of this chapter lies in the conceptualization of the political in policy making. An important political issue is the distribution of wealth across Europe, and specifically the extent to which concentrations of wealth are deemed acceptable or even desirable. Moreover, and in contrast to many policy studies, we locate the political beyond the realm of the expressive. Decisive political aspects may actually be contained within institutional forms, methods of policy practice and in routine forms of action. Tracing these links serves to shed light on the performativity of policy ideas and approaches in a way that considers policy development not just as an evolutionary process based on successful assembly, but as something deeply penetrated by the way political views on what is tolerable and desirable work their way through the machinations of policy making and implementation, in terms of core imaginations and ambitions (‘a competitive European space economy’), as well as the measures employed.

Through its fundamentally empirical orientation, in which no *a priori* significance is placed on policy discourse, policy practice or ideologies, the policy assemblage approach presents a fundamentally open perspective. As a result, the policy assemblage perspective may provide a fruitful alternative to more deterministic approaches, such as ‘state restructuring’ perspectives and structural scalar narratives (Brenner, 2004; Jessop, 2004; Uitermark, 2003). The separation of the material–organizational and the expressive, coding and overcoding, the identification of nested structures of policy making, and the conceptualization of state impact ‘at a distance’ produces a more subtle empirically grounded approach sensitive to context and contingency. This comes with a risk, however. Without *a priori* ideas of where to look for important phenomena, a researcher may be tempted to select those items that, at face value, appear to be most fitting to explain policy dynamics. Rather than revealing the complex political nature of policy making, this may then lead to a somewhat crude social–evolutionary form of explanation, in which social phenomena are explained primarily in terms of fitting, well-packaged forms of coding and territorialization. There is a pressing need, accordingly, to further elaborate this approach to make it truly stand up to its promises.

REFERENCES

- Amin, A. and Thrift, N. (1993), 'Globalization, institutional thickness and local prospects', *Revue d'Économie Régionale et Urbaine*, 405–27.
- Anderson, B. and Harrison, P. (2010), 'The promise of non-representational theories', in B. Anderson and P. Harrison (eds), *Taking-place: Non-Representational Theories and Geography*, Farnham, UK: Ashgate, pp. 1–34.
- Arts, B. and Lagendijk, A. (2009), 'The disoriented state', in B. Arts, A. Lagendijk and H. van Houtum (eds), *The Disoriented State: Shifts in Governmentality, Territoriality and Governance*, Dordrecht: Springer, pp. 231–47.
- Bachtler, J., Wishlade, F. and Mendez, C. (2007), 'New budget, new regulations, new strategies: The 2006 reform of EU Cohesion Policy', Glasgow, European Policies Research Centre, University of Strathclyde.
- Bachtler, J., Wishlade, F. and Yuill, D. (2003), 'Regional policies after 2006: complementarity or conflict?', Glasgow, European Policies Research Centre, University of Strathclyde.
- Barca, F. (2009) 'An agenda for a reformed cohesion policy. A place-based approach to meeting European Union challenges and expectations. Independent Report prepared at the request of Danuta Hübner, Commissioner for Regional Policy', Brussels: Commission of the European Communities.
- Boschma, R.A. (2005), 'Proximity and innovation: a critical assessment', *Regional Studies*, 39, 61–74.
- Brenner, N. (2004), *New State Spaces: Urban Governance and the Rescaling of Statehood*, Oxford: Oxford University Press.
- Brenner, N. and Theodore, N. (2002), 'Cities and the geographies of "actually existing neoliberalism"', *Antipode*, 34, 349–79.
- CLOE (2007), *Cluster Management Guide – Guidelines for the Development and Management of Cluster Initiatives*, Karlsruhe: Clusters Linked Over Europe.
- Colebrook, C. (2002), *Gilles Deleuze*, London: Routledge.
- Collier, S.J. and Ong, A. (eds) (2005), *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*, Oxford: Blackwell.
- Cooke, P. (1985), 'Regional innovation policy – problems and strategies in Britain and France', *Environment and Planning C – Government and Policy*, 3, 253–67.
- Cooke, P. and Morgan, K. (1998), *The Associational Economy: Firms, Regions and Innovation*, Oxford: Oxford University Press.
- Cumbers, A., Mackinnon, D. and McMaster, R. (2003), 'Institutions, power and space – assessing the limits to institutionalism in economic geography', *European Urban and Regional Studies*, 10, 325–42.
- DeLanda, M. (2006), *A New Philosophy of Society: Assemblage Theory and Social Complexity*, London and New York: Continuum.
- EC (2006), *Communication from the Commission. Regions for Economic Change*, Brussels: Commission of the European Communities, Directorate-General for Regional Policy.
- EC (2008), *Good Practice in the Field of Regional Policy and Obstacles to the Use of the Structural Funds*, Brussels: Commission of the European Communities, Directorate-General for Regional Policy, Policy Department Structural and Cohesion Policies.
- European Commission (1996), *Practical Guide to Region Innovation Actions. Regional Innovation Strategies (RIS). Regional Innovation and Technology*

- Transfer Strategies (RITTS)*, Luxembourg: Office for Official Publications of the European Communities.
- Ewers, H.J. and Wettmann, R.W. (1980), 'Innovation-oriented regional policy', *Regional Studies*, **14**, 161–79.
- Foray, D. (2006), *Globalization of R&D: Linking Better the European Economy to 'Foreign' Sources of Knowledge and Making EU a More Attractive Place for R&D Investment*, Brussels: European Commission.
- Gertler, M.S. (2001), 'Best practice? Geography, learning and the institutional limits to strong governance', *Journal of Economic Geography*, **1**, 5–26.
- Hillier, J. (2000), 'Going round the back? Complex networks and informal action in local planning processes', *Environment and Planning A*, **32**, 33–54.
- Howells, J. (2005), 'Innovation and regional economic development: a matter of perspective?', *Research Policy*, **34**, 1220–34.
- IRE (2006), *Mutual Learning Platform. Synthesis Report*, Luxembourg: Innovating Regions in Europe.
- IRE (2008), *The IRE Network: Inspiring Innovation Innovating Regions in Europe (IRE)*, Luxembourg: Innovating Regions in Europe.
- Jessop, B. (2004), *From Localities via the Spatial Turn to Spatio-temporal Fixes: A Strategic-relational Odyssey*, Bonn: University of Bonn.
- Jessop, B. (2009), 'Cultural political economy and critical policy studies' *Critical Policy Studies*, **3**, 336–56.
- Legendijk, A. (2007), 'The accident of the region: a strategic relational perspective on the construction of the region's significance', *Regional Studies*, **41**, 1193–207.
- Legendijk, A. and Cornford, J. (2000), 'Regional institutions and knowledge – tracking new forms of regional development policy', *Geoforum*, **31**, 209–18.
- Laranja, M., Uyarra, E. and Flanagan, K. (2008), 'Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting', *Research Policy*, **37**, 823–35.
- Latour, B. (2005), *Reassembling the Social. An Introduction to Actor-Network-Theory*, Oxford: Oxford University Press.
- Loasby, B.J. (1998), 'Industrial districts as knowledge communities', in T.M. Bellet and C. L'Harmet (eds), *Industry, Space and Competition. The Contribution of the Economists of the Past*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 70–85.
- MacLeod, G. (2001), 'Beyond soft institutionalism: accumulation, regulation, and their geographical fixes', *Environment and Planning A*, **33**, 1145–67.
- Massey, D. (2005), *For Space*, London: Sage.
- McFarlane, C. (2009), 'Translocal assemblages: space, power and social movements', *Geoforum*, **40**, 561–7.
- Molle, W.T.M. (1983), 'Technological change and regional development in Europe', *Papers of the Regional Science Association*, **52**, 23–38.
- Oughton, C., Landabaso, M. and Morgan, K. (2002), 'The regional innovation paradox: innovation policy and industrial policy', *Journal of Technology Transfer*, **27**, 97–110.
- Porter, M.E. (2000), 'Locations, clusters and company strategy', in G.L. Clark, M.P. Feldman and M.S. Gertler (eds), *The Oxford Handbook of Economic Geography*, Oxford: Oxford University Press, pp. 253–74.
- Prince, R. (2010), 'Policy transfer as policy assemblage: making policy for the creative industries in New Zealand', *Environment and Planning A*, **42**, 169–86.
- PRO INNO (2009), *Annual Report 2008–2009. Working Towards More Effective*

- Innovation Support in Europe*, Brussels: Commission of the European Communities, European Regional Development Fund.
- Reid, A. (2008), *Analysing ERDF Co-financed Innovative Projects. Final Report Prepared in the Framework of the European Commission Study on the ERDF Co-financed Innovative Projects and Comparative Analyses*, Brussels: Technopolis Group.
- Sassen, S. (2006), *Territory, Authority, Rights. From Medieval to Global Assemblages*, Basingstoke: Palgrave Macmillan.
- Shore, C. and Wright, S. (1997), 'Policy. A new field of anthropology', in C. Shore and S. Wright (eds), *Anthropology of Policy: Critical Perspectives on Governance and Power*, London: Routledge, pp.3–40.
- Soete, L. (2009), *The Role of Community Research Policy in the Knowledge-based Economy. Expert Group Report*, Brussels: European Commission, Directorate-General for Research.
- Tewdwr-Jones, M. and Morais Mourato, J. (2005), 'Territorial cohesion, economic growth and the desire for European "balanced competitiveness"', *Town Planning Review*, **76**(1); 69–80.
- Thrift, N. (1997), 'The rise of soft capitalism', *Cultural Values*, **1**, 29–57.
- Thrift, N. and Olds, K. (1996), 'Refiguring the economic in economic-geography', *Progress in Human Geography*, **20**, 311–37.
- Todtling, F. and Trippel, M. (2005), 'One size fits all? Towards a differentiated regional innovation policy approach', *Research Policy*, **34**, 1203–19.
- Torring, J. (2011), 'Policy, discourse models', in IPSA (ed.), *Encyclopedia of Political Science*, Thousand Oaks, CA: Sage.
- Uitermark, J. (2003), *The Multi-scalar Origins of Urban Policy: Towards a Policygenetic Approach*, Research programme Governance and places, Nijmegen, the Netherlands: Nijmegen School of Management.
- Van Heur, B. (2008), 'Networks of aesthetic production and the urban political economy', Department of Earth Sciences, Berlin, Freie Universität Berlin.
- Varró, K. (2010a), 'After resurgent regions, resurgent cities?: contesting state geographies in Hungary and England', Nijmegen, University of Nijmegen.
- Varró, K. (2010b), 'Re-politicising the analysis of "new state spaces" in Hungary and beyond: towards an effective engagement with "actually existing neoliberalism"', *Antipode*, **42**, 1253–78.
- Ward, K. and Jonas, A.E.G. (2004), 'Competitive city-regionalism as a politics of space: a critical reinterpretation of the new regionalism', *Environment and Planning A*, **36**, 2119–39.

PART III

The Future of Innovation and Prospects for Socio-Economic Integration

6. Innovation diplomacy as driver of democracy, innovation and development: the case of Greece

Elias G. Carayannis

1. INTRODUCTION

Chapter 1 touched briefly on innovation diplomacy as a means of bridging distance and other divides. It can unleash and help ‘realize the creative potential and aspirations of people around the world so that markets will serve society . . . to the fullest possible extent’ (Carayannis et al., 2011). We now build on that background to examine the current situation of and prospects for Greece.

In general, entrepreneurship and innovation are human endeavors and socio-economic phenomena that are intrinsic to human nature as well as constituting both social and political engines of positive change and growth provided they are balanced and guided by effective and transparent regulatory and incentive systems in place.

Current local (Greek), regional (European) and global economic and financial conditions and trends make the need to trigger, catalyze and accelerate high-quantity and -quality entrepreneurial initiatives that are based on high-quality and -quantity innovations (low-tech, medium-tech and high-tech) even more clear and urgent as this is one of the major ways and means to target and achieve real, sustainable and eventually accelerating GNP growth. Such growth is much more likely to come from new and qualitative different and superior initiatives (from ‘sunrise’ industries) rather than restructuring existing (and perhaps ‘sunset’) industries. It may be strategically more prudent to invest scarce and precious resources in carefully calculated strategic ‘bets’ rather than keep throwing them after waning industrial sectors and declining firms and in that sense, it may be best to provide aggressive socio-economic re-training, re-insertion and/or early retirement programs to allow for real growth strategies to be implemented.

Moreover, we believe that the concepts of robust competitiveness and sustainable entrepreneurship (Carayannis et al., 2008) are pillars of a

regime called ‘democratic capitalism’ (Carayannis and Kaloudis, 2009) (as opposed to ‘popular or casino capitalism’), where real opportunities for education and economic prosperity are available to all and especially the younger people.

This would be the direct derivative of a collection of top–down policies as well as bottom–up initiatives (including strong R&D policies and funding but going beyond that to the development of innovation networks and knowledge clusters across regions and sectors: Carayannis and Campbell, 2006):

- We define sustainable entrepreneurship (Carayannis et al., 2008) as the creation of viable, profitable and scalable firms. Such firms engender the formation of self-replicating and mutually enhancing innovation networks and knowledge clusters (innovation ecosystems) leading towards robust competitiveness.
- We understand robust competitiveness (Carayannis et al., 2008) as a state of economic being and becoming that avails systematic and defensible ‘unfair advantages’ to the entities that are part of the economy. Such competitiveness is built on mutually complementary and reinforcing low-, medium- and high-technology, public and private sector entities (government agencies, private firms, universities and non-governmental organizations).

Existing and new small and medium enterprises (SMEs) that can provide better solutions for less will always be winners – even and perhaps especially in down markets and recessionary economic cycle stages – and this is the area where fiscal, monetary, institutional, intellectual property rights (IPR)-related and other public–private sector programs and initiatives are needed to help unlock, capture and leverage fully the value-adding potential of the Greek knowledge creation infrastructure (i.e. universities, research institutions and private sector R&D facilities) by providing incentives and establishing a large number, scale and scope of pilots connecting organically and effectively all stages of the value-adding knowledge chain (from the lab to the market via world-class SMEs that will be both locally as well as globally oriented by design and the new ones from their inception).

2. OPEN INNOVATION DIPLOMACY

Building on the constituent elements of technology transfer and commercialization, open innovation diplomacy encompasses the concept and

practice of bridging distance and other divides (cultural, socio-economic, technological) with focused and properly targeted initiatives to connect ideas and solutions with markets and investors ready to appreciate them and nurture them to their full potential. With respect to Greece, we recommend the development of efforts and initiatives as follows (Carayannis, 2011).

2.1 The What

1. Re-engineer mindsets, attitudes and behaviors in Greece to help people – especially young people – realize the true nature and potential of innovation and entrepreneurship as a way of life and the most powerful lever for and pathway to sustainable growth and prosperity, with positive spillover effects staunching the brain-drain, reduced cynicism and increased optimism and trust in the future and each other, reduced criminality and social unrest, higher assimilation of migrant groups and similar effects.
2. Engage in sustained, succinct and effective dialog with stakeholders and, policy makers within Greece as well as the EU to pursue the reform and, as needed, the reinvention of institutions, policies and practices that can foster entrepreneurship and innovation in areas such as related laws, rules and regulations, higher education, public and private R&D, civil society movements and non-governmental organizations.
3. Identify, network and engage purposefully and effectively with the Greek diaspora of professional and social networks to trigger, catalyze and accelerate their involvement and intervention in a focused and structured manner to help with goals 1 and 2 above, as well as help establish, fund and manage entrepreneurship and innovation, promoting and supporting initiatives and institutions such as business plan competitions, angel and other risk capital financing of new Greek ventures, mentoring of and partnering with these ventures to ensure their survival, growth and success both within Hellas and in the global markets. Of particular interest and importance would be communities of practice and interest among the Greek diaspora that would include the shipowners, large trading concerns and technology entrepreneurs in countries such as the USA, Canada, Australia, as well as the EU and the rest of the world.

2.2 The How

Greek companies (especially small- and medium-sized firms) need to begin with the high-quality tools and expertise at their disposal (in terms

of business planning, risk capital financing guidance and sources as well as strategic partners, complementors, suppliers and customers – in short a business ecosystem they can thrive locally, regionally and globally).

1. This should begin with a mindset shift from short-term, survival-mode thinking, which is normal for entrepreneurs especially in their early business stages, to more strategic, globally as well as locally attuned thinking and acting which nowadays could be greatly enabled and empowered via social networking tools and methodologies as well as blended (real/virtual) teaching/learning/consulting/mentoring environments.
2. Moreover, in the case of a country like Greece, a local, regional and global perspective is critical, given the small size of the local market. In this regard, Greece should pursue an effective and efficient strategic integration of its knowledge-generating assets in the universities as well as its industry and its government sectors and leverage them fully along with EU and Greek diaspora resources, expertise and experience to promote the creation of a new breed of start-ups (preferably – but not exclusively – as high-tech as is sustainable technologically and commercially).
3. These start-ups would aim to form a critical mass of an entrepreneurial innovation ecosystem in the form of locally and globally internetworked and competitive firms that would more organically and sustainably allow Greek innovators and entrepreneurs to tap and expand into the world's markets while remaining, researching and creating in Greece.
4. I have called this concept 'co-location' in the sense that it aims to retain the knowledge creators and potential entrepreneurs based in their mother country while enabling them to set up a bridgehead and become active in larger markets such as the USA. I have been doing this for the last five years with some success with Hellenic high-tech spin-offs from R&D centers and universities in Greece co-locating in the USA.
5. A balanced approach with a win–win–win mindset is key, combining short-term with long-term considerations. People, culture and technology need to be organically aligned so that resources used lead to results obtained in as short a period as possible to establish credibility and gain cooperation and support from civil society.
6. For that, top-level champions are needed as well as a strategic leveraging of social networking structures and infrastructures. In the past, regions around the world – whether Silicon Valley in California, or the Route 128 region in the Boston area or others – have been identified as

success benchmarks for innovation and entrepreneurship. However, simply emulating those has not always led to success, as people and culture are finicky and there are higher-order interdependencies and complexities involved.

3. POLICIES AND FRAMEWORKS

Here are some ideas as to how to set up policies and frameworks to provide conditions as conducive as possible to the creation of a sustainable and competitive entrepreneurship and innovation ecosystem in Greece:

- Advocate the need for a non-political, institutionally and meritocratically established entity that would function as part of the government in Greece and all other EU countries and could be called ‘Ministry for Innovation and Entrepreneurship’ but set up in a flexible manner to avoid becoming part of the problem.
- Advocate the need for an ‘Ombudsman for Entrepreneurs and Innovators’ with proper authority, visibility and resources to intervene and resolve barriers to innovation and entrepreneurship (E&I) in Greece and across the EU (this is the institutional civil society role in support of E&I as part of the quadruple innovation helix concept: Carayannis and Campbell, 2009), with government, university and industry working effectively with civil society to support and promote E&I).
- Advocate the need for high-caliber volunteers among the Greek diaspora as mentors as well as potential risk capital investors and strategic partners – in this context, I would propose forming a ‘Global Greek Diaspora Angel Investor Network’ and ‘The Global Greek Diaspora Bond Issue for Entrepreneurs & Innovators’ and to have the funds managed by a professional entity that is subject to the diaspora members in a transparent and efficient manner. The intent would be to allow for a pooling of resources, so, along with large-scale donations, many small-sized but cumulatively substantial contributions could start being made on a streamlined and sustainable basis and always focused on supporting and promoting E&I initiatives and efforts (a working case of that can already be seen in Denmark where a micro-finance and micro-enterprise fund – ‘My C 4’ – is already succeeding in pooling thousands of investors, with thousands of entrepreneurs leveraging social networking and clear vision and execution: www.myc4.com).

4. ENTREPRENEURS AND ACADEMICS

My descriptions of entrepreneurs and academics, based on 20 years of experience working with academics as well as entrepreneurs, are as follows:

- Entrepreneurs exhibit strongly the attributes of ‘obsessed maniacs’ focused on realizing their vision and ‘clairvoyant oracles’ seeing the opportunities and how to exploit them ahead of all others and being able to share that vision effectively with their key partners, investors and other early stakeholders (Carayannis, 2000–2010, Carayannis and Formica, 2006, 2007). A case in point is Daniel Williamson and the venture ‘Connexions’, which he is helping to develop further (www.cnx.org).
- Academics ideally should be ‘entrepreneurs of the mind in the business of growing people intellectually and spiritually’ (Carayannis, 2007) – facilitators of a lot of ‘happy accidents’, that is knowledge exchanges and partnerships.

Based on these descriptions, one should aim to inspire, empower and liberate the individual aspiring entrepreneurs (whether academic researchers and/or graduate students in science and engineering as well as other fields) to dare to dream big and dream in scientific/technological as well as commercial terms and to dare to take the next huge step of forming a company and asking people to invest in their dreams.

One of the ways to do so would be to establish across all Greece’s universities interlinked, complementary and reinforcing, cross-disciplinary graduate degrees focused on E&I with emphasis on practice and aiming to produce working prototypes in the related science and engineering fields of the participants (from medical devices to agricultural techniques to software programs) and provide support and guidance for proper follow-through leading to the establishment of intellectual property rights (patents, trademarks, copyrights, trade secrets) as well as the formation of companies to commercialize those prototypes. These companies should be supported by advisory boards as well as potential investors from both internal/domestic networks as well as the Greek diaspora including the ‘Global Greek Diaspora Angel Investor Network’ mentioned above.

5. THE GREEK–US BRIDGE

In the mind of the average American, Greece is a country associated with its history and culture, the weather and the landscape and its famous

Mediterranean diet.¹ Other than that the Greek economy has little to offer, let alone compete with in the fields of innovation, state-of-the-art technologies, disruptive solutions, modern entrepreneurship and the like.

Every Greek economic actor, from the trade offices the Greek state maintains in the USA to the bilateral chambers (i.e. the Greek–American Chamber of Commerce and similar entities), to the trade and business development agencies in Greece, to Greek companies seeking to do business in the USA, all face this long-lived and largely misleading prejudice. But, to those who have first-hand knowledge or prefer to dig a little further beneath the surface, things look different.

Despite the economic downturn there is a dynamic economic and innovation potential in today's Greece, which remains to a large extent untapped. This potential can be ascribed to three main factors:

1. Native human capital: scientists and researchers, doctoral and post-doctoral candidates, graduates of world-class universities and polytechnics, fellows in major institutes and research facilities, who return home and staff local academic institutions or start their own companies right out of their labs.
2. The entrepreneurial spirit: Greeks have been archetypical for their adjustability and innovative thinking throughout history, having not only survived but flourished in unfriendly terrains and uncharted markets. A recent example illustrating this spirit is the unprecedented penetration Greek companies have accomplished in South-east Europe in the early 1990s, in a very volatile political, business and investment environment right after the collapse of the former Soviet bloc. Today, in some countries in the Western Balkans, Greek FDI stock ranks first among foreign investors, outpacing economic giants like Germany, the UK and the USA.
3. Smart thinking: inventive academics and business pioneers had to virtually bypass a systemic defect in the Greek R&D framework: the decoupling of basic from applied research, leading to a correlated decoupling of innovation from industry and markets.² Applied research was practically transferred away from the universities, where mainly basic research is conducted, to research centers and tech parks, where commercializing technology and creating tech-driven start-ups are much less complicated.

How well Greece scores in winning competitive EU funding is an indicator of both the existence and the impact of the above-mentioned factors when combined and applied in a proper manner and in a highly antagonistic environment. Table 6.1 highlights the performance of Greek 'players'

Table 6.1 EU funding for ICT: calls for proposals 1–5 (Dec. 2006 through Oct. 2009) (percentage (%) of final funding allocated per member state)

Country	1st call 12/2006– 5/2007	2nd call 6/2007– 10/2007	3rd call 12/2007– 4/2008	4th call 11/2008– 4/2009	5th call 7/2009– 10/2009	Total average/ rank
Greece	4.79	4.64	2.73	4.46	4.20	4.16 (3)
Austria	4.18	2.83	5.30	3.72	3.46	3.89 (4)
Belgium	4.88	5.36	3.21	6.11	4.65	4.84 (2)
Denmark	1.22	1.36	0.39	1.65	1.23	1.17 (8)
Finland	3.30	3.84	0.97	1.81	2.35	2.45 (6)
Ireland	1.38	1.24	0.75	1.19	4.37	1.78 (7)
Netherlands	6.37	5.04	6.39	6.82	4.53	5.83 (1)
Sweden	4.08	5.11	2.49	3.57	3.59	3.76 (5)

compared to other member states in winning competitive EU funding in information and communication technologies (ICT), one of the most innovative and competitive sectors.³

Greece ranks third and almost on par with Belgium, ahead of globally recognized R&D and innovation ‘role models’ Sweden and Finland, and also the equally advanced Nordic economy, Denmark, in front of the reputed international FDI ‘magnet’ Ireland and dynamic Austria. This is a very positive sign for the Greek innovative ICT sector.

As a further qualitative indicator, in the 1st call (12/2006–5/2007), for example, 35.8 percent of all the submitted proposal (total: 1836) had a participating Greek entity and 85 of the total 318 successful (= funded) proposals (or 26.7 percent) had a Greek participation. Furthermore, 20 out of a total of 135 of the submitted proposals under Greek coordination were approved, a remarkable 14.8 percent success rate.

6. THE GREEK RENAISSANCE INITIATIVE

The stability and sustainability of the Greek economy and society are of strategic importance for Europe as well as the USA, given the geopolitical, geo-economic, geo-strategic and geo-technological (geo-STEP) interdependencies across the region and beyond.

Unfortunately, short-sightedness and short-termism among politicians and policy makers in Europe and the USA have led to an exacerbation of the situation and a slow and increasingly risky series of balancing acts (as

I write this, Greece has been assessed at being in ‘selective default’ with serious risk of both sudden and catastrophic deterioration as well as broad contagion effects).

The conceptual foundation of the Greek renaissance initiative rests upon the following ideas:

- Current stratospheric unemployment levels, especially among the young, constitute a moral failure and a self-destructive crime against the society and economy of a country that it is absolutely critical to control, mitigate and reverse. One answer may be the effort as it is unfolding in the University of Ioannina Innovation Odysseys Initiative (<http://ok2012.uoi.gr>) as well as other universities around Greece and in cooperation with angel and mentor networks in Europe and the USA, where about 30 researcher and entrepreneur teams are entering the process of business plan development, evaluation, and presentation to potential investors including seed funding, foundation and co-location of start-ups at the University of Ioannina Technology Park and locations in the USA, for instance the George Washington University Science and Technology Ecosystem.
- If these efforts reach critical mass and result in the formation and growth of an E&I ecosystem that is present in Greece as well as in other countries and markets, via the co-location of university spin-offs, we may see a new middle class emerge that is empowered with the wisdom of global and local experience as well as the resources and capacity to act as part of the Global Greek Entrepreneurship and Innovation Ecosystem, bridging markets and pushing the endless frontier of science, technology and innovation further forward.
- This new and emerging middle class of global entrepreneurs and innovators would also act as the foundation, platform and protective buffer for a new era of open, transparent and democratic institutions, dynamics and processes in Greece and help in the emergence and evolution of political parties and mechanisms that would be more empowered as well as accountable and transparent.

These efforts, however, need time, perseverance, esthetic sensibility and structured and disciplined use of knowledge, know-how, experience and expertise. That is why it is critical for the Greek Renaissance Initiative to succeed to have a team from among experienced, successful and inspired members of the global Greek diaspora (researchers, academics, entrepreneurs, investors, policy makers and other professionals) and could set the pace and prove the concept for a way forward which could also constitute a working prototype for the entire EU.

This would indeed establish sufficient opportunities, bridging of markets and leveraging of net-centric knowledge serendipity and arbitrage effects that could well transform the current dire brain-drain from Greece and other European countries into a formidable brain-gain (via both the physical presence of repatriated innovators and entrepreneurs as well as the virtual presence, participation and contributions of all others engaged in support of start-ups in Greece).

7. CONCLUSION: LESSONS LEARNED AND RECOMMENDATIONS FOR THE ROAD AHEAD

I believe that academics are – or should continually strive to become – entrepreneurs of the mind in the business of growing people intellectually, spiritually and socially. Entrepreneurship is, in my experience, a liberator of creativity and an enabler of inventiveness that converts human dreams into socio-economic realities. I consider teaching, research and outreach as three key pillars of the academic enterprise that are mutually complementary and reinforcing. Successful entrepreneurs are typically people of a certain character, culture and charisma that leverage the financial means they have earned to do good in a multitude of ways. In the same context, through my research and pedagogy, I have come to qualify entrepreneurs of any type – including those of the mind who, by the way, represent the dominant mode in a knowledge economy and society – as obsessed maniacs and clairvoyant oracles. I have been involved for a number of years, and on a voluntary, *pro bono* basis, in designing and implementing initiatives to help reform and revitalize the Greek education ecosystem and, in particular, the higher education component as it relates to the national innovation and entrepreneurship ecosystem of Greece.

The challenge and opportunity is to engage on a large enough scale to both upgrade existing SMEs and catalyze the formation of new ones with an expectation to both survive and prosper as well as to grow (Greece should aim to be the cradle of the next Google or Amgen in the next 10–15 years as the nature and dynamics of the underlying technologies demand resources that are now well within the grasp of Greek researchers and potential or current entrepreneurs). The real challenge is to convert past failures of courage and imagination into future successes and to learn to convert counterproductive cynicism into empowering dreams grounded in reality. The aim should be to identify and outline clearly and in a convincing manner to all Greek citizens (including those of the diaspora, especially communities of interest and practice including diaspora members as well as other innovation ecosystem stakeholders as potential partners

and mentors of domestic current and aspiring entrepreneurs – especially younger ones) a vision for the future and a strategy for change that is comprehensive, feasible and convincing so as to overcome the ‘cynicism premium’ that politics in Greece has to pay to atone for prior failures of omission and commission. In short, we believe that the E&I area is one of the key pillars on which a strategy for change that people can believe in can be built.

Specific areas of focus should be clean/green technologies, environmental remediation/recovery solutions, eco-tourism and other higher-value (lower cost–benefit ratios) tourism solutions, transportation/connectivity solutions, nano-biomedical therapies, advanced materials for civilian and other uses, organic farming to feed the world, generic medicines to heal the world, e-learning solutions to educate the world (many of these should be set up as regionally centered, EU-supported initiatives).

Some more examples and thoughts of where and how E&I interventions might be targeted are listed below:

- (a) Entrepreneurship as a solution for the way ahead – make a bigger pie, don’t just redistribute it.
- (b) Environment and energy as key sectors for entrepreneurial initiative – destroy the monopolies and bring on democratic capitalism (see Carayannis and Kaloudis, 2009).
- (c) New technologies as platforms for flexible and high-value-added manufacturing – use intangibles to build valuable tangibles as they are the cause of viable, long-term prosperity (not services in a globalized, slave-labor-cost-driven economy).
- (d) Eco-tourism building on environmental remediation and safeguarding and green energy schemes as drivers of entrepreneurial initiative – Greece is the Saudi Arabia of renewable energy and should be a major green energy exporter.
- (e) Generic medicines and organic foodstuff not only for Greece but also parts of the world (like Africa) where they are dearly needed (and GMOs cause harm) – this could again leverage Greek know-how with UNIDO/WB/EBRD/EIB funding schemes and become a major and targeted (and also protected) export driver.
- (f) Trans-disciplinary university pilot programs where students from engineering, medicine, business and social sciences are brought together into practice-focused apprentice groups to support existing firms and help create new ones in a network of internetworked incubators across universities, R&D centers, and other locations of private sector firms and feed the experiences and lessons learned back into curriculum renewal and design.

These are examples of building and implementing the quadruple innovation helix concept and the MODE 3 knowledge production system (see Carayannis and Campell, 2009; see also chapter 1). This is happening in many North and Western European countries today, and we need to engage in Greece as well.

In closing, we wish to note that people are interested in solutions that they can relate to and trust in to make things better for them individually and socially and in a viable manner. Greece remains the land of Alexander and Ulysses and, by extension, Greeks within Greece may choose to embrace defeat and decline or rediscover the voices, dreams, innovation, entrepreneurship and competence of Alexander, Ulysses and their comrades at arms and reinvent and re-build modern Greece and its socio-economic and socio-political ecosystems, locally, regionally and globally.

NOTES

1. In a recent market analysis on US consumers' attitudes towards Greece and Greek products (Kairos Consumers for the Greek Exporters Association, October 2010: www.pse.gr/en), the test groups associated Greece with nothing but historical/cultural and geographical landmarks (i.e. Acropolis, ancient history, Pythagoras, islands, Athens etc.) and food products (i.e. feta cheese, olives, yogurt etc.). To the question 'Which 3 products would you label as "made in Greece"?' the responses further solidified the findings: ouzo, feta cheese, olive oil, grape leaves, yogurt etc. As one quoted answer perfectly epitomizes: 'Olives, olive oil, feta cheese, yogurt; I can't think of any other products that are produced in Greece other than food.'
2. Article 16 of the Greek Constitution, which regulates Education, Art and Science, especially the correlation of provisions 'Art and science, research and teaching shall be free and their development and promotion shall be an obligation of the State' (§1): 'Education constitutes a basic mission for the State and shall aim at the moral, intellectual, professional and physical training of Greeks' (§2) and 'Education at university level shall be provided exclusively by institutions which are fully self-governed public law legal persons. These institutions shall operate under the supervision of the State (. . .)' (§5) of this article has been widely and consistently (mis)interpreted as practically forbidding any kind of commercial implications (let alone exploitation) of academic research.

This idealization (one is tempted to say sanctification) of academic research limited the transformation of research to tangible novel goods and procedures, despite the fact that a number of targeted laws have been enacted to revert that distortion. Paragraph 3A of law 2741/1999 (further amended in 2000 by law 2843) clearly states that 'The outcomes of research and the knowledge created in research centers, educational institutions, companies or other entities in Greece and abroad can be economically exploited in various ways, including:

- a. Direct commercial use by producing and trading goods or services from the very knowledge-producing institution. In case the entity is an academic institution, those activities can be undertaken by the companies managing the institution's property.
- b. Out-licensing the commercialization from the knowledge-creating institution to a third-party entity or company, under a concession agreement defining the economic terms.
- c. Founding a targeted subsidiary corporation or participating in a third-party company to commercialize the knowledge produced.
- d. Technology companies where the economically-exploitable knowledge-creating

individuals (scientists, technologists and researchers) engage in entrepreneurial activity; the institution where the knowledge was created can participate in these companies in any desirable form as can third parties (individuals or legal persons).

e. A combination of any of the above mentioned forms and other ways.'

3. The mix of countries is arbitrary, chiefly by virtue of comparable size with Greece, yet also reputation and significance in the R&D and innovation field. Data provided by Directorate of International S&T Cooperation, European Union Division of the Greek General Secretariat of Research & Technology (www.gsrt.gr) and the Greek national contact points for EU ICT programs.

REFERENCES

- Carayannis, E.G. (2000–2010), GWU Lectures on Science, Technology, Innovation and Entrepreneurship.
- Carayannis, E.G. (2007), 'Higher education manifesto', *Industry & Higher Education*.
- Carayannis, E.G. (2011), 'The open innovation paradigm and strategic options for EU–US innovation partnerships: the FREIE concept in the context of open innovation diplomacy', Keynote Lecture, BILAT Conference, Vienna, Austria, March.
- Carayannis, E.G. and D. Campbell (2006), *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters: A Comparative Systems Approach across the United States, Europe, and Asia*, Westport, CT: Praeger Publishers.
- Carayannis, E.G. and D. Campbell (2009), "'Mode 3" and "Quadruple Innovation Helix": toward a 21st-century fractal innovation ecosystem', *International Journal of Technology Management*, **46**(3/4), 201–34.
- Carayannis, Elias G. and D. Campbell (2011), 'Open innovation diplomacy and a 21st-century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the "Mode 3" knowledge production system', *Journal of the Knowledge Economy*, **2**(3), 327–72.
- Carayannis, E.G. and P. Formica (2006), 'Intellectual venture capitalists: an emerging breed of knowledge entrepreneurs', *Industry & Higher Education*, **20**(3), 151–6.
- Carayannis, E.G. and P. Formica (2007), 'The concentration of resources and academic performance: reinventing learning and research in the 21st century', Guest Editorial in *Industry & Higher Education*, **21**(2), 121–3.
- Carayannis, E.G. and A. Kaloudis (2009), *Japan Economic Currents*, January, 6–10.
- Carayannis, E.G., A. Kaloudis and Å. Mariussen (2008), *Diversity in the Knowledge Economy and Society: Heterogeneity, Innovation and Entrepreneurship*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
- Carayannis, E.G., M. Provance and N. Givens (2011), 'Knowledge arbitrage, serendipity, and acquisition formality: their effects on sustainable entrepreneurial activity in regions', *IEEE Transactions on Engineering Management*, **58**(3), 564–77.
- Information Technology and Innovation Foundation (ITIF) (2010), 'Refueling the U.S. innovation economy', Washington, DC: ITIF.

APPENDIX

This appendix is adapted from an interview by *The Lithuanian Business Daily* provided by the author in October 2010.

1. *What is the importance of technology innovation for economic growth?*

Innovations (high-, medium- and low-tech) are the oxygen of the economy and the key driver of economic growth.

- (a) They are *socio-technical solutions* with higher value added (or units of benefit per unit of cost) compared to existing solutions, thus resulting in the expansion and improvement of current markets and/or the creation of new markets.
- (b) The more innovative an economy and a society is (the knowledge economy and society goal is pointing in that direction), the higher its productivity levels and thus the higher the rate of improvement of the standard of living (per capita GNP) and the more sustainable those higher productivity levels thanks to their higher levels of competitiveness.
- (c) In particular, a combination of high-quality and -quantity technology innovations allows an economy to keep winning in the global competition race by being sufficiently and consistently better in terms of value-added solutions (products and services) – Germany is a case in point with its *Mittelstand* (small- and medium-sized) firms.

2. *How can technology innovation help us exit from the economic crisis?*

As in the above comments, the more innovation-driven an economy becomes, the more sustainably competitive it will become and thus the more market share it will be able to claim from competitors, NOT on the basis of being cheaper but on the basis of being better on a comparative value-added basis.

- (a) In this context, the USA is currently mistakenly – in my opinion – trying to compete on being cheaper via ‘competitive dollar devaluations’. This is only a temporary and limited solution with an increasing intrinsic risk for the US dollar to cease being the pre-eminent reserve currency and a potential spiralling of its already very high borrowing costs.
- (b) In the EU context, this would require a combination of balanced and well-coordinated top-down government, university and industry

sector policies and mandates as well as bottom-up initiatives and practices from individuals and grass-roots movements (civil society) (the elements of the quadruple innovation helix discussed below).

- (c) Otherwise, ‘the entrepreneurship and innovation fad’ risks becoming just another concept with limited or unrealized potential that could further exacerbate the cynicism and disengagement of the polity.
3. *What are the tools for firms to adopt innovations successfully and what are the accruing innovation benefits for the business?*

Companies (especially small and medium-sized firms) need to begin with as high quality tools and expertise at their disposal as possible (in terms of business planning, risk capital financing guidance and sources, as well as strategic partners, complementors, suppliers and customers – in short a business ecosystem they can thrive in locally, regionally and globally).

- (a) This should begin with a mindset shift from only short-term, survival-mode thinking, which is normal for entrepreneurs especially in their early business stages, to more strategic, globally as well as locally attuned thinking and acting, which nowadays could be greatly enabled and empowered via social networking tools and methodologies as well as blended (real/virtual) teaching/learning/consulting/mentoring environments.
- (b) Moreover, in the case of a country like Lithuania, a local, regional and global perspective would be critical given the small size of the local market. In this regard, Lithuania should pursue an effective and efficient strategic integration of its knowledge-generating assets in the universities (this is also further discussed later) as well as its industry and its government sectors and leverage them fully along with EU and Lithuanian diaspora resources, expertise and experience to promote the creation of a new breed of start-ups (preferably – but not exclusively – as high technology as is sustainable technologically and commercially).
- (c) These start-ups would aim to form a critical mass of an entrepreneurial innovation ecosystem in the form of locally and globally internetworked and competitive firms that would more organically and sustainably allow Lithuanian innovators and entrepreneurs to tap and expand into the world’s markets while remaining researching and creating in Lithuania.
- (d) I have called this concept ‘co-location’ in the sense that it aims to retain the knowledge creators and potential entrepreneurs based in their mother country while enabling them to set up a bridgehead and

become active in larger markets such as the USA. I have been doing this for the last five years with some success with Hellenic high-tech spin-offs from R&D centers and universities in Greece co-locating in the USA.

4. *Can you explain the ideal cooperation plan between business and education organizations seeking commercial success for products or services? Please give some examples from practice.*

First of all, there is no ‘perfect’ cooperation plan – any such plan needs to be a living and evolving entity adapting to domestic and global socio-economic and technological trends and changes.

- (a) As per my above comments, a balanced approach with a win-win mindset is key combining short-term with long-term considerations. People, culture and technology need to be organically aligned so that resources used lead into results obtained in as short-term a context as possible to establish credibility and gain cooperation and support from civil society.
- (b) For that, top-level champions are needed as well as a strategic leveraging of social networking structures and infrastructures. In the past, regions around the world – whether the Silicon Valley in California, or the Route 128 region in the Boston area or others – have been identified as success benchmarks for innovation and entrepreneurship. However, simply emulating those has not always led to success, as people and culture are finicky and there are higher-order interdependencies and complexities involved.
- (c) Here are some ideas as to how to set up policies and frameworks to provide as conducive as possible conditions for the creation of a sustainable and competitive entrepreneurship and innovation ecosystem:
 - (c1) Advocate the need for a non-political, institutionally and meritocratically established entity that would function as part of the government in Lithuania and all other EU countries and could be called ‘Ministry for Innovation and Entrepreneurship’ but set up in a flexible manner to avoid becoming part of the problem.
 - (c2) Advocate the need for an ‘Ombudsman for Entrepreneurs and Innovators’ with proper authority, visibility and resources to intervene and resolve barriers to innovation and entrepreneurship (E&I) in Lithuania and across the EU (this is the

institutional civil society role in support of E&I as part of the quadruple innovation helix concept I have written about (Carayannis and Campbell, 2009, 2011) – government, university and industry working effectively with civil society to support and promote E&I).

- (c3) Advocate the need for high-caliber volunteers among the Lithuanian diaspora as mentors as well as potential risk capital investors and strategic partners – in this context, I would propose forming a ‘Global Lithuanian Diaspora Angel Investor Network’ and ‘The Global Lithuanian Diaspora Bond Issue for Entrepreneurs & Innovators’ and to have the funds managed by a professional entity that is subject to the diaspora members in a transparent and efficient manner. The intent would be to allow for a pooling of resources, so along with large-scale donations, many small-size but cumulatively substantial contributions could start being made on a streamlined and sustainable basis and always focused on supporting and promoting E&I initiatives and efforts.
- (d) Moreover, my descriptions of entrepreneurs and academics, based on 20 years of experience working with academics as well as entrepreneurs are as follows:
 - (d1) Entrepreneurs exhibit strongly the attributes of ‘obsessed maniacs’ focused on realizing their vision and ‘clairvoyant oracles’ seeing the opportunities and how to exploit them ahead of all others and being able to share that vision effectively with their key partners, investors and other early stakeholders.
 - (d2) Academics ideally should be ‘entrepreneurs of the mind in the business of growing people intellectually and spiritually’ (Carayannis, 2007).
 - (d3) Based on these descriptions, one should aim to inspire, empower and liberate the individual aspiring entrepreneurs (whether academic researchers and/or graduate students in science and engineering as well as other fields) to dare to dream big and dream in scientific/technological as well as commercial terms and to dare to take the next huge step of forming a company and asking people to invest in their dreams.
 - (d4) One of the ways to do so would be to establish across all of Lithuania’s universities interlinked, complementary and reinforcing, cross-disciplinary graduate degrees focused on

E&I with emphasis on practice and aiming to produce at their conclusion working prototypes in the related science and engineering fields of the participants (from medical devices to agricultural techniques to software programs) and provide support and guidance for proper follow-through leading to the establishment of intellectual property rights (patents, trademarks, copyrights, trade secrets etc.) as well as the formation of companies to commercialize those prototypes. These companies should be supported by advisory boards as well as potential investors from both internal/domestic networks as well as the Lithuanian diaspora including the Global Lithuanian Diaspora Angel Investor Network and others.

5. *What is the key to obtaining financing: cooperation or acting alone?*

First of all innovation is a team effort, so some type of cooperation (including co-opetition or collaborating with your competitors under the right sets of conditions) is a *sine qua non*.

- (a) The first key challenge typically is to bridge/overcome the so-called ‘valley of death’ hurdle – the lack of financing for early-stage ventures to get to the next level of growth and beyond a level of financing easily achieved with one’s own resources.
- (b) The comments above are part of the answer, and also patient and persistent policies and strategies that will nurture the development of an innovation ecosystem and the re-engineering of the mindsets of potential entrepreneurs and investors so that they will work better together and become better risk takers and risk evaluators over time.

6. *Could you compare US and European practices in the innovation-adopting area? Why is USA the leader in that? Do you have any suggestions for the scientists who are potential innovators?*

The USA retains an apparently eroding lead (see ITIF, 2010) thanks to earlier efforts starting with the Second World War, to promote E&I and also more E&I-friendly fiscal policies as well as the presence of a more accessible and large enough market.

- (a) Fragmentation of markets, bureaucracy, lack of transparency, lack of the right mindsets, impeding fiscal and monetary policies – all

these help to contribute to make things more difficult in Europe. However, there are many rays of hope in many regions across Europe, where clusters of innovative companies and innovation networks across regions and industries have been emerging. The Baltic region may well be the next one in this trend.

- (b) Moreover, this trend can be further reinforced via a comprehensive and focused strategy to empower individual start-ups or spin-offs to be created in Lithuania with the intent and the underlying strategy to target and benchmark against competitors in the USA and to plan and enact entry in the USA from very early on. This strategy of ‘co-location’ is described above.

7. *Do incentive prizes help catalyze innovation? Why?*

Incentive prizes always help trigger invention and catalyze innovation (such as the X Prize in the USA, among others) but they can not suffice to ensure both high-quality as well as -quantity innovation beyond isolated events (‘happy accidents’ again). For sure, they help focus people’s minds and provide them with an opportunity to compete with each other and also attain an apparent achievable goal.

8. *What is the importance of academic education as a pillar and driver of innovation?*

Academic education is key in order to provide the technical literacy and readiness to understand and leverage the messages nature is sending us and which we tend to realize through observing and learning from nature with an educated eye. In this regard, albeit there are cases of entrepreneurs who made it big with minimal education, education that is also tied organically with practice is a sine qua non for technology-driven innovation and entrepreneurship in particular.

9. *Do you think that fundamental or applied science is more useful for the economy? Why?*

This is a pseudo-dilemma in my opinion. Applied science stands on the shoulders of basic science but it takes longer for the fruits of basic science to manifest their value-adding potential, so we need to plan for and support both basic and applied science but with appropriately long horizons in each case as both provide the knowledge foundation or ‘soil’ in which the seeds of invention need to take roots so that the tree of innovation can grow and prosper.

- (a) In this regard, the end of the cold war and the resulting shift in shorter-term priorities for the USA have to a considerable extent been very detrimental for the science enterprise in the USA and Vannevar Bush (President Roosevelt's Science Advisor who wrote a seminal report entitled *Science: The Endless Frontier* in 1946) would consider 1989 the beginning of the end of the 'Endless Frontier' as we have come to know it.
 - (b) Of course, the US society and economy have been shown capable of adapting and overcoming any and all challenges cast upon them to date – and the jury is still out as to whether, over the long run, more or less democratic regimes are more or less innovative.
10. *What are your recommendations for the Lithuanian business and scientific community? We have a great lack of cooperation between science and business.*

As I mentioned above, a major shift in mindset from 'tactical fragmentation' to 'strategic integration', both within Lithuania and across government, university, industry and civil society as well as across the Baltic states, the EU and the world – and surely the USA. More specifically, some initiatives that may need to engage both the Lithuanian society and government as well as the Lithuanian diaspora (LD) are:

- (a) A strategically flexible, non-political and supra-governmental, civil-service-type 'Ministry for Innovation and Entrepreneurship', led and staffed by independent experts (domestic and foreign) as well as members of the LD primarily and on a non-career basis.
- (b) The formation of an Office of the Ombudsman for Entrepreneurs and Innovators (OOEI) again independent and supported by LD members and other non-political entities, foundations etc.
- (c) The Global Lithuanian Angel Investor Network and the Global Lithuanian Diaspora Bonds for Entrepreneurs and Innovators Initiative to provide, in a transparent and professionally managed manner, seed funding and risk capital for Lithuanian (primarily but not exclusively) high-technology inventor-entrepreneurs and surrogate entrepreneurs who are ready to develop the linchpins of the Lithuanian knowledge economy and society over the next ten years (let us call this initiative Lithuania 2020 to parallel the EU's Europe 2020 Plan and also to remind us of what was not accomplished with the Europe 2010 Lisbon Plan to help us learn and, we hope, avoid repeating the same mistakes twice at the country or continent levels.

- (d) To establish across all of Lithuania's universities interlinked, complementary and reinforcing, cross-disciplinary graduate degrees focused on E&I with emphasis on practice and aiming to produce at their conclusion working prototypes in the related science and engineering fields of the participants (from medical devices to agricultural techniques to software programs) and provide support and guidance for proper follow-through, leading to the establishment of intellectual property rights (patents, trademarks, copyrights, trade secrets etc.) as well as the formation of companies to commercialize those prototypes. These companies should be supported by advisory boards as well as potential investors from both internal/domestic networks as well as the Lithuanian diaspora including the Global Lithuanian Diaspora Angel Investor Network and others.

7. Spatial knowledge spillovers within and between European regions: a meta-analysis¹

Urban Gråsjö, Charlie Karlsson and Peter Warda

1. INTRODUCTION

During the last decade we have been able to observe a veritable explosion of interest in ‘knowledge spillovers’. A search using Google Scholar on April 2011 limited to ‘business, administration, finance and economics’ gave 18 000 hits of which more than 70 per cent were from the period 2002–11. This explosive increase in interest in the concept among researchers mirrors both an increased scientific interest and an increased interest among policy makers in the topic. The increased interest among researchers is undoubtedly stimulated by the developments in endogenous growth theory during the two last decades. Among policy makers, we can trace a substantially increased interest in ‘knowledge spillovers’, not least among those within Europe. In fact, 75 per cent of the 18 000 hits contain the word ‘Europe’. In Europe, it is in particular within the European Union (EU) that ‘knowledge spillovers’ have come into focus. The Lisbon Agenda confirmed by EU leaders in March 2000, which aims to create a climate in Europe that stimulates innovation, competitiveness and economic growth, has put ‘knowledge spillovers’ on the European policy agenda.

The earliest reference to ‘knowledge spillovers’ that we have been able to find is Griliches and Lichtenberg (1984, p. 466), who define ‘pure knowledge spillovers’ as ‘the cross-fertilization of one industry’s research program by developments occurring in other industries’, that is, as inter-industry spillovers. However, it should be observed that research and development ‘spillovers’ were discussed in, for example, Griliches (1979). These early contributions to the study of knowledge spillovers all disregarded the effect of ‘the tyranny of distance’ on knowledge spillovers; that is, they were totally non-spatial. It was not until the 1990s that researchers started to study the geographical extent of knowledge spillovers (Jaffe et

Table 7.1 Number of hits using Google Scholar, 10 April 2011

Search term	Number of hits	Number of hits when Europe is added
Interregional knowledge spillovers	89	84
Inter-regional knowledge spillovers	47	44
Regional knowledge spillovers	345	289
Local knowledge spillovers	487	399
Geographic knowledge spillovers	122	93
Geographical knowledge spillovers	123	111
Spatial knowledge spillovers	293	193
Intraregional knowledge spillovers	8	8
Intra-regional knowledge spillovers	20	18

al., 1993; Audretsch and Feldman, 1996). We found the first use of the term 'inter-regional knowledge spillovers' in Premer and Walz (1994), the first use of 'regional knowledge spillovers' in Englmann and Walz (1995), the first use of 'local knowledge spillovers' in Head et al. (1995) and Englmann and Walz (1995), the first use of 'geographic knowledge spillovers' in Anselin et al. (1997), the first use of 'spatial knowledge spillovers' in Keilbach (1998), the first use of 'intra-regional knowledge spillovers' in Dohse (2000) and the first use of 'geographical knowledge spillovers' in Wallsten (2001). In Table 7.1, we illustrate the total number of hits for all these terms according to Google Scholar on 10 April 2011. We can observe that an overwhelming majority of the publications dealing with spatial aspects of knowledge spillovers also contains some kind of reference to Europe.

The interest in spatial knowledge spillovers has its background in that the existence of localized knowledge spillovers is one possible explanation for the industrial clustering that we can observe (Krugman, 1991, 1998) – a clustering that is greater than would be expected if the geographic distribution of firms and jobs were random (Ellison and Glaeser, 1997). Evidences of knowledge spillovers that are geographically bounded have been found in many studies (see, e.g., Jaffe, 1989; Jaffe et al., 1993). However, many existing studies have explored these issues only within large geographic units, such as nations, states or very large regions such as the NUTS-2 regions within the EU, which has made it impossible to determine in more detail the spatial reach of knowledge spillovers (Wallsten, 2001). Since firms in an industry normally cluster at a finer spatial scale even within cities, and since the hypothesis is that firms located in proximity to each other benefit from knowledge spillovers, most studies give little specific

information about how distance as well as the local firm density matter for knowledge spillovers.

How should we understand this huge interest in spatial aspects of knowledge spillovers in general and in Europe in particular? One obvious reason is the long-standing observation that regions within integrated economic areas such as the EU tend to diverge rather than converge with regard to per capita incomes and labour productivity. This is of course puzzling, not least for many economists. The observed patterns of divergence are not in line with the predictions of the spatial version of the neoclassical growth model, where mobility of capital and labour over the long run would even out differences between regions (Borts and Stein, 1964). Neither are they in line with the more recent endogenous growth theory *à la* Romer (1986, 1990) and Lucas (1993), which builds upon the presumption that new knowledge is instantaneously and freely available to all economic agents because knowledge is assumed automatically and instantaneously to spill over from the economic agent generating the knowledge to all other economic agents.

In a similar manner, Griliches (1992) perceived that knowledge would spill over from the economic agent investing in new knowledge to be used by other economic agents at low or no cost. Knowledge can spill over and thus generate externalities since, being an intellectual asset, it differs from other factors of production by being non-exclusive and non-rivalrous (Arrow, 1962) and thus generating appropriability problems for those economic agents generating new knowledge. Even if knowledge can spill over, it does not imply that spillovers are automatic and instantaneous. New knowledge is highly uncertain and context specific, and is primarily diffused by means of face-to-face interaction, which implies that the diffusion of new knowledge is associated with high transaction costs. Hence early diffusion of new knowledge tends to be geographically limited to a spatial scale that allows frequent face-to-face interaction, which is normally equal to the daily interaction space of people. The spatial diffusion of knowledge is associated with frictions, which increase with distance, which gives a clear advantage to locations where knowledge-generating activities for one reason or another have started to cluster. However, economists have in the postwar period developed various explanations for divergent economic development in different regions, such as the theory of development poles (Perroux, 1955), theories of cumulative causation in economic growth (Myrdal, 1957; Dixon and Thirlwall, 1975) and theories of economic agglomeration, such as the 'new economic geography' (Krugman, 1991), which highlights the links between economic integration and agglomeration.

To understand the diverging development within the EU and within

its member states we need a theoretical framework that is able to explain the interaction between economic integration, the location of peoples and economic activities, and long-run growth in a system of regions. That growth affects location and location affects growth has strong theoretical foundations. It is in principle a basic characteristic of all endogenous growth models that they depend upon technical externalities in the form of knowledge spillovers or production externalities. That such externalities are connected with the spatial distribution of R&D activities and/or production has been documented empirically (see Eaton and Kortum, 1996). Against this background it is natural to assume that agglomeration of production and/or R&D activities will stimulate growth and that growth will stimulate agglomeration of production and/or R&D due to the existence of the actual externalities.

Thus there exists a theoretical framework capable of explaining the dynamic interaction between location and growth in a system of regions, when externalities are present. However, to understand the importance and spatial scale at which the actual externalities operate, we need detailed empirical studies. Thus there is a need to establish the pervasiveness of externalities based upon geographical proximity as well as the distances over which they operate (cf. Head et al., 1995). In the sequel, we will focus on one type of such externalities, namely knowledge spillovers. The empirical studies of the effects of knowledge spillovers in Europe have normally focused on the localized effects on either total factor productivity or knowledge production measured in terms of patent output.

The purpose of this chapter is to quantitatively review the empirical literature on spatial knowledge spillovers in Europe by means of meta-analysis to determine the extent to which such spillovers have been empirically documented, as well as their spatial reach. In addition, we will apply meta-regression analysis to analyse the determinants of observed heterogeneity across and between studies. Thoroughly assessed empirical information on these issues is particularly important for the design of policies at the EU, the national and the regional level aimed at increasing knowledge production.

Meta-analysis can be described as a set of statistical and econometric methods that can be used to summarize, analyse and evaluate the empirical results from a set of primary studies focusing on a specific research question (Stanley and Jarrell, 1989; Stanley, 2001). It offers a more systematic and objective way to evaluate the results from a number of empirical studies compared to conventional literature reviews, which have difficulties in comparing different empirical studies due to differences in theoretical frameworks, empirical models, econometric methods and data definitions. Meta-analysis makes it possible to statistically analyse the variation over

studies by means of basic economic variables and variations in research design. By applying meta-analysis to empirical studies of knowledge spillovers in Europe, we will be able to estimate the effect of knowledge spillovers on total factor productivity and knowledge production in Europe as well as the spatial reach of these effects, which is of great interest to policy makers interested in promoting economic growth in Europe.

The outline of this chapter is as follows: Section 2 discusses spatial knowledge spillovers by definition, methodological approaches and some stylized facts. Section 3 presents the meta-analysis and the results from gathering the data for the meta-regression analysis. The chapter offers an overview of the meta-sample and descriptive statistics from the publications that have been analysed in order to obtain a sample. Section 4 comprises the meta-regression analysis. Here we present our methodology, empirical model and analysis. Two models are estimated, one for local knowledge effects and the other for spillover knowledge effects. The final section concludes.

2. SPATIAL KNOWLEDGE SPILLOVERS

2.1 Definitions

Griliches (1979, p. 104) describes ‘knowledge spillovers’ as ‘working on similar things and hence benefiting much from each other’s research’. However, there is of course no guarantee that both parties gain or even gain equally when knowledge diffuses between economic agents. The principal idea behind the use of the concept ‘knowledge spillovers’ is that they are associated with externalities; that is, that knowledge generated by one economic agent can be used by other economic agents without any compensation paid to the generating economic agent who has carried the costs for the knowledge generation. However, it is important that knowledge may flow as a result of knowledge transactions or as a by-product of other transactions and that ‘pure knowledge spillovers’ only make up a (possibly minor) part of all knowledge flows. The implication is that not all knowledge flows are associated with externalities (Breschi and Lissoni, 2009).

Karlsson and Johansson (2006) argue that from the perspective of a firm one can separate three groups of knowledge flows that may generate knowledge spillovers:

- transaction-based knowledge flows,
- transaction-related knowledge flows, and
- pure knowledge spillovers.²

Table 7.2 Classification of knowledge flows to a firm

Knowledge flow category	Knowledge flow type
Transaction-based flows:	● Flows from knowledge providers that sell knowledge that is used as an input to a firm's R&D activities ● Flows in the form of inventions (innovations) that are sold to a firm (e.g. by licensing a patent) ● Knowledge flows between firms that cooperate in an R&D project, where costs and benefits are regulated by an explicit or an implicit contract, which may or may not be associated with unintentional knowledge spillovers ● A firm obtains access to knowledge via a merger or an acquisition
Transaction-related flows:	● A flow of knowledge that is embodied in the delivery of inputs from an input supplier to a firm ● In the course of supplying inputs to a firm, knowledge from the input supplier spills over unintentionally to the input-buying firm ● In the course of supplying inputs to a firm, knowledge from the input-buying firm spills over unintentionally to the input-selling firm
Pure spillover flows	● Unintentionally, knowledge spills over from one firm to a competing firm in the same industry ● Unintentionally, knowledge spills over between firms belonging to different industries

Source: Karlsson and Johansson (2006).

The three categories are presented in Table 7.2 together with nine types of knowledge flows.

From a firm's point of view, one can make a distinction between upstream, downstream and horizontal knowledge and technology flows. Upstream knowledge flows are helpful in generating access to suppliers' knowledge and technology often embedded in inputs bought by a firm. Downstream knowledge flows include the sale of knowledge and technology to customers either as licences or embedded in products. Horizontal knowledge and technology flows include intended and unintended knowledge and technology flows between firms in the same industry. Upstream and downstream knowledge and technology flows are inter-sectoral, while horizontal knowledge and technology flows are intra-sectoral.

From Table 7.2 it is obvious that the extent to which knowledge

flows are associated with ‘externalities’ obviously varies a great deal between the different types of knowledge flows. It is also clear from the table that ‘knowledge spillovers’ and thus ‘externalities’ may exist also in cases where market mechanisms are operating. To the extent that knowledge flows are connected with externalities, we may make a distinction between three types of externalities, which also are the three main agglomeration forces according to the ‘new economic geography’ approach:

- pecuniary externalities, i.e. externalities due to market interactions;
- technological externalities, i.e. externalities due to non-market interactions;
- human capital externalities, i.e. externalities due to the mobility between firms of employees with embodied knowledge.

Breschi and Lissoni (2001) argue that it is important to improve the understanding of the transmission mechanisms of knowledge in addition to measuring knowledge spillovers by a rather limited set of indicators. There are several mechanisms that support and facilitate the transfer and diffusion of tacit as well as codified knowledge (cf. Arrow, 1994) and technology:

- education
- communication channels that are interactive and have a high bandwidth (e.g. e-mail, the Internet etc.)
- deliberate policy (e.g. organizations setting up scouting and knowledge intelligence units)
- R&D collaboration
- special activities of people in order to obtain and disseminate knowledge (e.g. gatekeepers, cf. Allen, 1977),
- mobility of people with the relevant knowledge and skills
- trade in goods and services
- trade in knowledge and technologies
- direct investments
- intra-firm knowledge management
- imitation and reverse engineering (cf. Verspagen, 1994).

It is important to observe that even if each of these channels or mechanisms can be seen as partly independent, they are often linked to each other in different ways. It is in this connection important to observe that international collaborations are also a significant and increasingly important channel for transfer of knowledge and technology in both the

private and the public sector (Archibugi and Coco, 2004). An increasing number of partnerships among firms, universities and public research centres as well as between individual researchers and inventors is a clear indication of the growing importance of collaboration (NSF, 2002). Collaboration permits the partners to share and acquire each other's expertise, thus enriching the overall know-how. It can function as a positive sum game, where the advantages outweigh the disadvantages even if the advantages are not always equally shared among partners (Archibugi and Lundvall, 2001). The total number and type of collaborations can be taken as a measure on the one hand of the vitality of the regional, national and international knowledge systems, and on the other hand as an indicator of the extent and types of knowledge and technology transfers. The attractiveness of the knowledge base of economic agents will determine the extent to which they are invited to participate in collaborative ventures.

However, due to spatial frictions, we can expect that different mechanisms for the transfer of knowledge and technology differ in their effectiveness in transferring knowledge and technology at different distances. As much knowledge and technology tends to have a degree of tacitness, to be highly complex and/or highly contextual, it is often assumed that knowledge spillovers are bounded in geographical space. This implies that it is important to understand why location matters for knowledge flows of different kinds (Autant-Bernard et al., 2007). We need not only understand the spatial reach of knowledge flows but also their time profile. There is also a need to understand the mechanisms by which different types of knowledge and technologies are transferred, why transfer is unequal over space and the implications in terms of innovative performance in different locations. To achieve a better understanding of knowledge flows and the mechanisms that stimulate innovation performance, there is a need to evaluate by means of meta-analyses the results of the numerous empirical studies of knowledge spillovers performed in recent years. Certainly, such a meta-analysis is not enough to understand why and how location matters. There is also a need for complementary analyses of phenomena such as mobility of researchers, foreign direct investments, R&D collaborations, imports of knowledge-intensive products and entrepreneurial activities using micro-data (Audretsch and Feldman, 2004). Furthermore, to evaluate fully the impact of the spatial dimension it is important also to consider the influence of other proximities than the geographical, such as technological, institutional, organizational and social. However, at least the three last of these proximities are a function, among other things, of geographical proximity.

2.2 Methodologies Employed in the Literature

2.2.1 Different methodological approaches

Studies of spatial knowledge spillovers fall within study field ‘geography of innovation’ (Karlsson and Manduchi, 2001; Audretsch and Feldman, 2004). One common approach here has been to estimate how the knowledge output of firms in different locations is influenced by the research and innovation activities of other firms in the same as well as other locations to determine the influence of proximity on knowledge output. The extent of knowledge flows and knowledge spillovers is generally measured by the patterns of patent and publication citations, technology licensing or the degree of co-patenting and co-publication activities of researchers at universities and research institutes and in industry (Jaffe et al., 1993; Audretsch and Feldman, 1996; Crespi et al., 2006; Ponds et al., 2007).³

Many researchers think that patent citations can be used as a measure of technological impact and knowledge spillovers, in the sense that one specific technological innovation explicitly detects several others as being the technological state-of-the-art on which it is based. Patent citations have been used to analyse questions concerning spatial knowledge spillovers (see, e.g., Jaffe et al., 1993) and spillovers from public research (see, e.g., Jaffe and Trajtenberg, 1996; Jaffe and Lerner, 1999). However, patent citations are by no means a perfect measure of knowledge spillovers or flows since citations to patents not known to the inventor(s) may be added in the patenting process. Thus patent citations are a noisy measure but they have a substantial information content (Jaffe et al., 2000).

Many studies have focused only on disentangling the effects of ‘pure’ non-market ‘knowledge spillovers’, that is, technological spillovers, but attempts have also been made to estimate the effects of market-based knowledge flows (Autant-Bernard and Massard, 2007; Miguélez and Moreno, 2010).

2.2.2 The knowledge production function approach

According to Feldman (1999), it is possible to categorize studies of knowledge effects in regions into four types: (i) geographic knowledge production functions; (ii) paper trails left in patent citations; (iii) ideas in people; or (iv) ideas in goods. Studying the literature reveals a clear dominance of the use of geographic knowledge production functions and this approach is also the focus of our meta-analysis. The framework for analysing the importance of knowledge and knowledge spillovers for innovative activity is usually based on the knowledge production function (KPF) of Griliches

(1979). The framework was later developed with a geographical dimension by Jaffe (1989).

Spatial spillovers and spatial dependence can be accounted for in various ways. Following Anselin (2003), the spatial effects can be either (i) unmodelled, (ii) modelled or (iii) both unmodelled and modelled. If the spatial spillovers are global, that is, every location is correlated with every other location, but the correlations decreases with distance, the inclusion of a spatial multiplier effect of the form $(I - \lambda W)^{-1}$ models the spatial effects. Equations (7.1) to (7.3) show the three structural forms.

$$\text{Unmodelled effects: } y = x\beta + (I - \lambda W)^{-1}u \quad (7.1)$$

$$\text{Modelled effects: } y = (I - \lambda W)^{-1}x\beta + u \quad (7.2)$$

$$\text{Both effects: } y = (I - \lambda W)^{-1}x\beta + (I - \lambda W)^{-1}u \quad (7.3)$$

with $(I - \lambda W)^{-1} = I + \lambda W + \lambda^2 W^2 + \dots$ and $|\lambda| < 1$

where y is the dependent variable, W is a spatial weight matrix, λ is a spatial autoregressive parameter, x is a matrix of independent variables, β is a vector of regression parameters and u is a vector of independent disturbance terms, $u \sim N(0, \sigma^2)$.⁴

The question is then which model to choose. The answer depends very much on the case under study. Let us assume that the objective is to find to what extent R&D can account for the variations in regions' patent production.

- If the interest is limited to the local effects of R&D; that is, how R&D conducted in region i affects patent production in region i , then the answer is unmodelled effects.
- If the interest is to find both the local effects and the spatial spillovers of R&D; that is, how patent production in region i is affected by R&D efforts in municipality $i, j, k, \dots$, then the answer is modelled effects.
- If the interest is to estimate local effects of R&D and spatial dependencies of patent production; that is, how patent production in region i is affected by patent production in region $j, k, \dots$, then the answer is both effects.

Our focus is to find and investigate studies that estimate the importance of spatial spillovers of explanatory variables (studies with 'modelled effects').

2.3 Stylized Facts

Botazzi and Peri (2000) estimate a production function of innovation for European regions using patent and R&D data for the period 1977 to 1995. The main aim of the paper is to analyse the geographical relation between market size and innovative activity. R&D employment and R&D expenditure are used as inputs for both local and spillover knowledge effects.⁵ The authors find that knowledge externalities exist within a geographical area of 200 kilometres; however, it decreases fast with increased distance. Thus knowledge spillovers are not strong enough to generate sustained growth in the region. One effect that might cause knowledge spillovers in Europe is that regions close to each other use similar technologies.

Another paper by Botazzi and Peri (2003) uses similar methodology, variables and time period, but different weighting techniques in terms of distance. The results show that knowledge spillovers exist within a 300-kilometre distance. Similar to the former study, the spillover effects to neighbouring regions are rather small, though large in the local region. Doubling the R&D expenditure in a region increases innovation by 2 to 3 per cent within a 300-kilometre distance, whereas the region itself benefits from an increase in innovation between 80 to 90 per cent.

Crescenzi et al. (2007) analyse the dynamics of innovation in a Europe–USA perspective using a knowledge production function framework. The focus is on a set of territorial processes that influence innovative activity. Local knowledge effects are estimated in terms of R&D expenditure as a share of regional GDP, whereas the spillover effects are weighted through a spatial average of neighbouring regions' R&D expenditure.⁶ They find that Europe is far behind the USA in innovation and technology. An imperfect market integration along with institutional and cultural barriers work against Europe in catching up with the USA. However, increased European integration through geographical processes such as advances in road systems, ICT and firm cooperation might help Europe to close the innovation gap.

Crescenzi and Rodrigues-Pose (2008) use multiple regression analysis to estimate effects from R&D, knowledge spillovers and proxies for regional innovation systems. A total of 25 EU members are analysed with the possibility to discriminate between local and non-local knowledge spillovers. Local knowledge effects are measured in terms of R&D expenditure as a share of gross regional product. The knowledge spillover inputs comprise weighted accessibility to extra-regional innovation. The empirical results show that the complex interaction between local and non-local research shapes the innovation capacity in all regions. Proximity is highly

important for knowledge creation, since spillovers are strongly affected when the distance increases.

The central focus in Hauser et al. (2008) is to analyse how innovation is spatially distributed between regions in Europe. The authors suggest that the spatial pattern of input variables (such as R&D expenditure and human capital) in innovation processes drives patenting autocorrelation, that is, knowledge spillovers. To prove this relationship they use a knowledge production function that measures innovative activity in form of patent applications. The local knowledge effect takes the form of R&D expenditure per worker. The empirical results show that there is a high degree of spatial autocorrelation in patent applications. The spatial location of the input variables has a significant effect on patent applications, and hence drives knowledge spillovers.

Krammer (2009) analyses the innovation impact in transition countries, before and after the fall of communism in Eastern European countries. Innovative output, as explained by the number of patents, is estimated by a knowledge production function. Various factors that measure innovative output are considered, such as: skill of labour, productivity, R&D investment, existing stock of knowledge and other factors that influence knowledge creation in transition countries. Local knowledge effects are estimated in terms of R&D expenditure (total, private and public). The results confirm that universities and the existing knowledge base (in the form of private and public R&D) have a crucial impact in augmenting the number of patents as countries go into transition.

In Maggioni et al. (2007) the focus is on geographical and relational spillovers to study the effects of patenting activity in regions within five European countries. They use a gravity model of co-patenting that explains how knowledge flows between inventors in one region and inventors in another region. The model incorporates private and public R&D expenditure in local and non-regions, technological similarities, geographical distance, common borders and so on. Another gravity model is suggested to study the effect of co-patenting in the local region. OLS (ordinary least squares) estimations show that private R&D expenditure induces larger spillover effects from one region to another than public R&D expenditure. Moreover, technological similarities are proven to have a positive effect on co-patenting between two regions.

Moreno et al. (2003, 2005) analyse the spatial distribution of innovative activity and technological spillovers across 138 and 175 regions, respectively, in 17 European countries. Both papers estimate, for different time periods, a knowledge production function of innovative activity. Local effects are explained by R&D expenditure as a share of GDP, whereas the spillover effects are estimated via contiguity matrices of R&D and

weight matrices with neighbours portion of local R&D up to 750 and 500 kilometres, respectively. In Moreno et al. (2003) the results show that spillovers are significant up to a distance of 500 km (i.e. up to a second-order neighbourhood). However, in Moreno et al. (2005) this relationship is only significant up to a distance of 250 km (i.e. up to a first-order neighbourhood). The results from both papers indicate that technological similarities between regions are important for knowledge to spill over.

In a working paper by Pinto (2010), the knowledge production function framework is adapted to analyse how regions within the EU transform specific inputs to local knowledge outputs (i.e. patents per capita). Panel data analysis is applied to 25 countries and 125 regions for the period 1999 to 2003. Local effects enter the knowledge production function in terms of private and public R&D expenditure as a share of GDP. The results show that private R&D expenditure tends to be more important for knowledge production in the local region.

Pinto and Rodrigues (2010) estimate a knowledge production function to draw conclusions on how regional innovation strategies have affected knowledge creation. A total of 175 European regions are analysed over the period 1994 to 2001. A model is fitted to explain how local knowledge, measured in terms of patents and high-technology patents, is related to local R&D activities. The knowledge production function uses private and public R&D expenditure as a share of regional GDP as input variables for local knowledge effects. The paper concludes that private R&D expenditure is of high relevance to increasing the number of patents within a region.

The purpose in Varga et al. (2010) is to analyse the effects of intra-regional agglomeration as due to R&D productivity across 189 regions within the EU. The study utilizes a knowledge production function that explains how innovation (in terms of patents) is related to a local knowledge variable in form of lagged gross regional R&D expenditure. The study observes that innovation flows are more than proportionate to R&D inputs. Moreover, agglomeration of innovation systems has a positive effect on R&D productivity. Thus knowledge interactions within European regions are of high importance for innovative activity to flow.

The central focus in Greunz (2003) is to study the effects of inter-regional knowledge spillovers across 153 European sub-national regions. A regional knowledge production function is fitted to answer the question whether geographical and technological proximities matter for knowledge creation in Europe. Knowledge spillovers are measured in terms of patents and are explained by a set of local and spillover knowledge inputs. R&D expenditure per capita (total, private and public) enters the function as a local knowledge input. The spillover knowledge variable is represented by

R&D expenditure weighted by distance to geographical neighbours. Inter-regional knowledge spillovers seem to exist between regions close to one another and between regions with technological similarities. Moreover, the empirical results show that knowledge spillovers in Europe are mainly driven by private R&D expenditure. However, given that knowledge spillovers exist within a nation, its national borders tend to dampen the spread of interregional knowledge flows further in Europe.

From the above 13 publications we have managed to extract local knowledge effects in all publications (110 observations). The local knowledge effect is frequently reported in terms of R&D expenditure. On the other hand, the spillover effect has been far more difficult to interpret due to various methodologies adapted in the empirical regression analysis of these publications. Thus we have been able to isolate only 75 observations from 7 of the above publications. Most commonly the spillover knowledge effect takes the form of R&D-weighted contiguity matrices.⁷

3. A SIMPLE META-ANALYSIS

3.1 The Meta-Sample

The data for the meta-analysis on knowledge spillovers in Europe were collected via an extensive search for studies that correspond to a set of lowest common denominators. The time period for the studies analysed ranges from 2000 to 2010. Key phrases used to find publications of interest comprise: ‘knowledge production function and Europe’ and/or ‘knowledge spillovers and Europe’. Additional requirements for a specific publication to be included in the analysis are: Europe must be the focus area; it applies quantitative methods; it includes a minimum of five European countries; and the publication must contain a specific knowledge coefficient measuring local and/or spillover effects from one region to another. Thus we are interested in publications that estimate spatial spillover effects using a knowledge production function framework for at least five European countries. Equation (7.4) presents a typical knowledge production function that has been encountered in the literature review:

$$Y_i = \alpha_0 + \beta_1 x_i + \beta_2 (Wx)_j + \sum_{k=1}^n \gamma_k z_{ki} \quad (7.4)$$

Y_i is the dependent variable indicating knowledge production (or output) in region i , for example through number of patents, patents per capita, total factor productivity or wages. x_i and x_j are the knowledge inputs in

Table 7.3 Meta-explanatory variables

1. Time period	2. Estimation method (e.g. OLS, GLS, ML)
3. Time lag between input and output (1, 2, ..., years)	4. Testing for spatial dependence (spatial autocorrelation tests)
5. Number of countries	6. Type of spatial model (spatial lag, spatial error, accessibility, distance band, nearest neighbour)
7. Coverage of economy (services, manufacturing or total etc.)	8. Type of main explanatory variable (R&D and human-capital-related variables)
9. Type of data (panel, cross-section)	10. Type of dependent variable (in form of patents, wages, total factor productivity)
11. Type of geographic unit (NUTS)	12. Other variables that characterize the publication

region i and j ($i \neq j$), respectively, and comprise indicators such as R&D employment, R&D expenditures and human capital in form of educated labour. W is a spatial weight matrix. z_{ki} is a vector that measures other covariates in region i . α_0 is the intercept coefficient and β_1 , β_2 and γ_k are coefficients. The variables Y , x and z can enter the function in log form depending on whether the structural form is additive by nature or multiplicative, for example taking the form of a Cobb–Douglas production function.

To perform the meta-regression analysis, the coefficient for β_2 (or β_1) needs to be specified in our empirical model as the dependent variable. Table 7.3 presents other meta-explanatory variables that have been considered when gathering information from the empirical literature on knowledge spillovers in Europe.

Most data for the Y_i variable in the relevant publications has been generated from the European Patent Office and Eurostat in the form of annual patent data. However, the main focus of the meta-analysis is aimed at the coefficients β_1 and β_2 , along with their standard errors. Estimators like these are often characterized by either marginal effects (i.e. additive) or in form of elasticities (i.e. multiplicative).

If the interest is to conduct a meta-analysis on spatial spillover effects, then β_2 is the relevant coefficient; that is, what influence knowledge input in region j has on knowledge output in region i . Many publications in our review have not isolated the spillover effect, which thus encourages a further gathering of information about β_1 (i.e. the local effect of

knowledge input). The majority of publications that fit our requirements have empirically analysed the effect of β_1 and used various weighting techniques to control for spatial dependence. In order to satisfy the aim of the meta-analysis, β_1 and β_2 are defined in equations 7.5 and 7.6:

$$\beta_1 = \beta_{Lip^c}, \quad (7.5)$$

$$\beta_2 = \beta_{Sjp^c}, \quad (7.6)$$

$$p = (1, 2, \dots, n) \text{ and } c = (1, 2, \dots, m)$$

where β_{Lip^c} is the local knowledge variable in region i and β_{Sjp^c} is the spillover knowledge variable in region j . The subscript term p refers to a specific empirical publication and c is the c^{th} β coefficient in publication p . From now on we use the terms β_1 and β_2 in our discussion.

3.2 Results of the Meta-Analysis

Table 7.4 presents an overview of the publications that have been analysed in the meta-analysis. Each publication displays a certain amount of information that has been gathered in order to generate a data sample. The variables reported include the number of β coefficients (i.e. how many of each β_1 and β_2 there are per publication), what type of local and spillover knowledge variable is utilized, number of countries, time period, geographical unit (i.e. NUTS), dependent variable and the number of observations used in the empirical application.

The local knowledge variable in region i is usually reported as R&D employment or R&D expenditure. An important point of discussion regards the large variation between the coefficients for β_1 and β_2 . Each publication has a unique approach to measuring knowledge production from one region to another (i.e. the knowledge inputs x_i and x_j differ a great deal between publications). While some use the total effect of R&D expenditure to measure spillovers, others apply the variable in per capita or per worker, as private or public expenditure, with natural logarithms or as a share of gross domestic product or gross regional product. Thus we need to evaluate carefully the implications of each specific measure of knowledge production spillovers in order to avoid any misinterpretation of the effect it has on the dependent variable (i.e. in Y_i).

The second column in Table 7.4 reports the total number of β coefficients per publication.⁸ Our total sample of publications that use a quantitative approach is equal to 13.⁹ Out of these, we have generated 110 β coefficients for the local knowledge variable in region i and 75 β

Table 7.4 Meta-analysis sample overview*

Publication (<i>p</i>)	β_1 coefficients per study	β_1	β_1 coefficients per study	β_2	European countries	Time period	NUTS	Dependent variable = Y_i	<i>N</i>
Botazzi and Peri (2000): WP	16	$\ln RD_{EMP}$ $\ln RD_{EMP/W}$ $\ln RD_{EXP}$	16	$\ln RD_{EMP}$ $\ln RD_{EMP/W}$ $\ln RD_{EXP}$ weighted by distance	12	1977–95	1/2	$\ln YP_{APP}$, $\ln YP_{APP/W}$	86
Botazzi and Peri (2003): WP	8	$\ln RD_{EMP}$ $\ln RD_{EXP}$	8	$\ln RD_{EMP}$ $\ln RD_{SPE}$ weighted by distance	12	1977–95	0/1/2	$\ln YP_{APP}$	86
Crescenzi et al. (2007): WP	6	$RD_{EXP\%/GRP}$	6	SWANR	8	1990–2002	1/2	$\ln YP_{APP}$	97
Crescenzi and Rodriguez-Pose (2008): J	11	$RD_{EXP\%/GRP}$	11	AERI TAIPS AIPEA AERI _{WEI}	15	1995–2003	1/2	$\ln GDP_{CAP}$	166
Hauser et al. (2008): J	1	$\ln RD_{EXP/W}$	0	N/A	6	Average 97/99/01	1	$\ln YP_{APP/C}$	51
Krammer (2009): J	16	$\ln RD_{EXP}$ $\ln RD_{EXPG}$ $\ln RD_{EXPB}$	0	N/A	16	1990–2007	1	PGY	126–221

Maggioni et al. (2007): J	4	RD _{EXPG%GDP}	0	N/A	5	1995–2001	1/2	P	51
Moreno et al. (2003): WP	13	RD _{EXPB%GDP} lnRD _{EXP%GDP}	12	lnRD weighted by distance	17	1978–97	1/2	lnP _{CAP}	123
Moreno et al. (2005): J	11	lnRD _{EXP%GDP}	9	lnRD weighted by distance	15	1978–2001	0/1/2	lnP _{CAP}	175
Pinto (2010): WP	4	RD _{G%GDP}	0	N/A	25	1999–2003	1/2	P _{CAP}	125
Pinto and Rodrigues (2010): J	4	RD _{B%GDP} lnRD _{EXPG%GRP} lnRD _{EXPB%GRP}	0	N/A	15	1994–2001	2	lnP lnHTP	175
Varga et al. (2010): WP	6	lnRD _{EXP}	0	N/A	23	2000–2002	1/2	lnP	567
Greunz (2003): J	10	lnRD _{EXP/C} lnRD _{EXPG/C} lnRD _{EXPB/C}	13	lnRD _{EXP} lnRD _{EXPG} lnRD _{EXPB} weighted by distance	14	1989–96	0/1/2	lnP _{CAP}	1184– 224
$\Sigma p = 13$	Total:		75						

Notes:

WP = working paper; J = article in journal.

* In order to fit Table 3.2 conveniently on to two pages, some meta-explanatory variables have been excluded in the presentation of the table. See Appendix for further details on the abbreviations in columns three (for β_1) and five (for β_2).

Table 7.5 Descriptive statistics for $\beta_1 = \beta_{Lip}$

Publication (<i>p</i>)	β_1 coeffi- cients	β_1				
		Mean	Std dev.	Median	Min.	Max.
Botazzi and Peri (2000): WP	16	0.966	0.100	0.965	0.830	1.280
Botazzi and Peri (2003): WP	8	0.855	0.065	0.835	0.790	0.960
Crescenzi et al. (2007): WP	6	0.369	0.449	0.395	-0.145	0.960
Crescenzi and Rodriguez-Pose (2008): J	11	0.171	0.037	0.166	0.137	0.268
Hauser et al. (2008): J	1	0.600	0.000	0.600	0.600	0.600
Krammer (2009): J	16	0.150	0.077	0.141	-0.050	0.274
Maggioni et al. (2007): J	4	0.230	0.323	0.235	-0.060	0.510
Moreno et al. (2003): WP	13	0.493	0.037	0.485	0.429	0.551
Moreno et al. (2005): J	11	0.260	0.022	0.257	0.225	0.294
Pinto (2010): WP	4	0.686	0.443	0.688	0.290	1.080
Pinto and Rodrigues (2010): J	4	0.237	0.346	0.256	-0.153	0.588
Varga et al. (2010): WP	6	0.833	0.160	0.780	0.688	1.082
Greunz (2003): J	10	0.320	0.194	0.400	0.030	0.570
$\Sigma p = 13$ Overall:	110	0.468	0.346	0.445	-0.153	1.280

Notes:

WP = working paper.

J = article in journal.

β_1 = local knowledge variable in region *i* derived from the *c*th β coefficient in publication *p*.

coefficients that measure the spillover of knowledge from region *j*. The number of countries that are analysed varies from 5 to 25, where most focus is on countries in the EU-15. The time period studied also differs between publications. Some begin as early as the 1970s, while other knowledge production functions are estimated from the mid-1990s and onwards.

A number of publications also mixes different geographical units. The most common unit varies between NUTS-1 (economic country-level data) and NUTS-2 (economic region-level data). Yearly patent applications and number of patents, in log form, take the form of the dependent variable in the majority of publications (i.e. the Y_i). The number of observations per empirical study (i.e. *N*) varies a great deal from one publication to another. The lowest number of observations is 51 and the highest is 1224.

Table 7.5 presents the descriptive statistics for the β_1 coefficients obtained from the 13 publications. The table includes the mean value, median, standard deviation from the mean value, as well as the lowest and highest value.

The publications we have analysed are issued in the period 2000 to 2010.

Table 7.6 Descriptive statistics for $\beta_2 = \beta_{Sip}$

Publication (<i>p</i>)	β_1 coeffi- cients	β_2				
		Mean	Std dev.	Median	Min.	Max.
Botazzi and Peri (2000): WP	16	0.071	0.027	0.080	0.032	0.110
Botazzi and Peri (2003): WP	8	0.022	0.009	0.027	0.004	0.030
Crescenzi et al. (2007): WP	6	7.982	0.466	8.118	7.066	8.311
Crescenzi and Rodriguez-Pose (2008): J	11	0.008	0.008	0.013	-0.008	0.014
Hauser et al. (2008): J	0	N/A	N/A	N/A	N/A	N/A
Krammer (2009): J	0	N/A	N/A	N/A	N/A	N/A
Maggioni et al. (2007): J	0	N/A	N/A	N/A	N/A	N/A
Moreno et al. (2003): WP	12	0.280	0.149	0.268	0.045	0.548
Moreno et al. (2005): J	9	0.035	0.023	0.049	-0.011	0.056
Pinto (2010): WP	0	N/A	N/A	N/A	N/A	N/A
Pinto and Rodrigues (2010): J	0	N/A	N/A	N/A	N/A	N/A
Varga et al. (2010): WP	0	N/A	N/A	N/A	N/A	N/A
Greunz (2003): J	13	0.169	0.055	0.170	0.040	0.240
$\Sigma p = 7$ Overall:	75	0.736	2.157	0.080	-0.011	8.311
$\Sigma p = 6$ Overall adjusted:	69	0.106	0.117	0.052	-0.011	0.548

Notes:

WP = working paper.

J = article in journal.

 β_2 = spillover knowledge variable in region *j* derived from the *c*th β coefficient in publication *p*.

They have been published either as working papers (WP) or as articles in journals (J). The number of β_1 coefficients varies per publication, from 1 to 16 coefficients, depending on how many regression models the publication has estimated. The mean value for the local knowledge coefficient is reported as between 0.150 and 0.966. The overall mean value of β_1 (i.e. for all 13 publications) is about 0.468, whereas the median is 0.445. The deviation from the mean of β_1 is high for some publications (e.g. Crescenzi et al., 2007; Maggioni et al., 2007; Pinto and Rodrigues, 2010), while it is low for others. The minimum and maximum values for the overall sample of β_1 coefficients are -0.153 and 1.280, respectively.

Table 7.6 reports the descriptive statistics for the knowledge spillovers from region *j* to region *i* (β_2). Out of 13 publications, 7 report coefficient values for β_2 . The mean value for β_2 falls within the range 0.008 to 7.982. The high mean value corresponding to 7.982 is observed in Crescenzi et al. (2007). The study uses a spatially weighted average composed of several factors that measure flows of knowledge spilling over from the

neighbouring region to the local region. It comprises various proxies that make it possible to measure accumulation of local skills. The spatially weighted average increases the estimated values of the spillover coefficients, however, excluding it from our sample would imply that we lose valuable information in identifying knowledge spillovers from one region to another.¹⁰ However, to avoid a misleading interpretation of the overall descriptive statistics of β_2 we also include descriptive statistics that are adjusted for the high values observed in Crescenzi et al. (2007) in Table 7.6.

The overall adjusted mean value for the spillover coefficient is 0.106 and the standard deviation is 0.117. The median is close to the mean for all publications, which indicates that each publication has a rather normal distribution in the spillover coefficient. The overall adjusted median is equal to 0.052 and a standard deviation of 0.117. The lowest and highest values for β_2 are -0.011 and 0.548 , respectively.

4. META-REGRESSION ANALYSIS

4.1 Methodology

A common econometric problem in meta-regression analysis is that observations from the same study can be correlated. Since we have used multiple estimates per study, the within-study dependence is accounted for by a static panel data framework called the cluster-specific random effects model (GLS-RE). Previous meta-analyses using this regression technique include Jeppesen et al. (2002), Disidier and Head (2008), and Melo et al. (2009). For comparison reasons we have also reported results from a standard OLS.

4.1.1 Meta-regression model

The general model utilized to analyse the local knowledge effects and the spillover of knowledge (i.e. β_z) in the meta-regressions is as follows:¹¹

$$\beta_z = a_z + \sum_{d=1}^{24} b_d D_d + \epsilon \quad (7.7)$$

$$z = 1, 2$$

The dummy variables D_d are defined in Table 7.7. The constant a_z is equal to the local (β_1) and the spillover effect (β_2), respectively, if b_d and/or D_d is equal to zero for all $d = 1, \dots, 24$. The parameter estimate b_d is zero when the chosen model cannot pick up any variations among observations

Table 7.7 Meta-dummy variables

Empirical dimension	Variable	Definition	Reference case, $D = 0$
Working paper or published in a journal	D_1	1 if working paper	Study published in journal
	D_2	1 if R&D per capita	Study uses log of total
Type of R&D variables	D_3	1 if R&D is not in log terms	R&D expenditure
	D_4	1 if R&D as a percentage of gross regional product (GRP)	
	D_5	1 if public (government) R&D	
	D_6	1 if business R&D	
	D_7	1 if inter-regional spillovers are accounted for	Study does not account for spatial spillovers
Spatial model	D_8	1 if R&D is weighted by physical distance between regions	R&D is weighted by a binary contiguity matrix
	D_9	1 if R&D in neighbouring regions	R&D in non-neighbouring regions
Spatial weighting regime	D_{10}	1 if p -value of local R&D > 0.05	Local R&D is significant at the 5% level
	D_{11}	1 if p -value of spillover R&D > 0.05	Spillover R&D is significant at the 5% level
Statistical significance	D_{12}	1 if average year of study period is after 1990	Average year of study period is before 1990
	D_{13}	1 if time lag between dependent and independent variables	No time lag between variables is used
Time structure	D_{14}	1 if regions from north, west and south only	Study includes countries from all parts of Europe (north, west, south and east)
	D_{15}	1 if regions from west and south only	
	D_{16}	1 if regions from east only	

Table 7.7 (continued)

Empirical dimension	Variable	Definition	Reference case, $D = 0$
Type of data	D_{17}	1 if panel data	Study uses cross-sectional data
Level of geographical unit	D_{18}	1 if NUTS-1 regions only	Study includes NUTS-2 regions
Dependent variable	D_{19}	1 if patents are not in log terms	Study uses log of patent applications as dependent
	D_{20}	1 if log patents per capita	
	D_{21}	1 if annual patent growth	
	D_{22}	1 if annual GRP growth	
Education level	D_{23}	1 if there are controls for higher education	Study does not control for differences in education level
Initial stock (patents or GRP value)	D_{24}	1 if initial stock is controlled for	Study does not control for initial stock of dependent variable

and studies. The dummy $D_d = 0$ demonstrates the case chosen as the reference case. The two models for explaining β_z differ in one respect. The model explaining variations in local effects does not include the variables about spatial weights (D_8 and D_9); instead the simple dummy for a spatial model (D_7) is used. Obviously, D_7 is excluded in the spillover model because when a spillover effect is estimated, this is done in a spatial model.

Due to a large amount of collinearities among the 24 dummies in equation 7.7, it is impossible to use all the variables simultaneously. In order to find the final models used in this chapter the following strategy was followed:

1. When two variables are collinear, omit the one with the lowest correlation to the β variable and save the other.
2. Continue with step 1 until the multicollinearity problem is sufficiently small.
3. Omit variables with statistical significance > 0.1 .

After fulfilling this strategy, the following two final models were estimated:

Table 7.8 Meta-regression results: dependent variable = local effect (β_1)

Dummy variable	OLS	GLS-RE
D_1 1 if working paper	0.291*** (0.053)	0.297*** (0.058)
D_5 1 if public (government) R&D	-0.235** (0.083)	-0.248** (0.099)
D_7 1 if interregional spillovers are accounted for	-0.165*** (0.040)	-0.062*** (0.023)
D_{10} 1 if p -value of local R&D > 0.05	-0.301*** (0.056)	-0.239*** (0.027)
D_{15} 1 if regions from west and south only	0.310*** (0.063)	0.233*** (0.072)
D_{22} 1 if annual GRP growth as dependent	0.257*** (0.062)	0.168*** (0.051)
D_{24} 1 if initial stock is controlled for	-0.170*** (0.028)	-0.200*** (0.034)
Constant	0.523*** (0.052)	0.482*** (0.061)
Number of observations	110	110
Number of studies	13	13
R^2 (total)	0.795	0.775
R^2 (within)		0.367
R^2 (between)		0.870

Note: ***, **, * indicate significance at 1%, 5% and 10% respectively. The standard errors in parentheses are robust to heteroscedasticity and adjusted for intra-study dependence.

$$\beta_1 = a_1 + b_1 D_1 + b_5 D_5 + b_7 D_7 + b_{10} D_{10} + b_{15} D_{15} + b_{22} D_{22} + b_{24} D_{24} \quad (7.8)$$

$$\beta_2 = a_2 + b_1 D_1 + b_3 D_3 + b_8 D_8 + b_{11} D_{11} + b_{15} D_{15} + b_{22} D_{22} + b_{24} D_{24} \quad (7.9)$$

4.2 Results from the Meta-Regressions

The results of the meta-regressions are presented in Tables 7.8 and 7.9. Let us focus on the results from the random-effects GLS regression reported in Table 7.8. The reference case is as follows: if total local R&D expenditure in a region increases by 1 per cent, then the number of patents in the region, on average, increases by 0.482 per cent. If a study uses a spatial model of some kind, that is, a model that takes into account R&D spillovers from

Table 7.9 *Meta-regression results: dependent variable = spillover effect (β_2)*

Dummy variable	GLS-RE	GLS-RE
D_1 1 if working paper	0.066*** (0.011)	0.057*** (0.004)
D_3 1 if R&D is not in log terms	7.769*** (0.026)	—
D_8 1 if R&D is weighted by physical distance between regions	0.093*** (0.024)	0.090*** (0.024)
D_{11} 1 if p-value of spillover R&D > 0.05	-0.142* (0.087)	-0.074** (0.046)
D_{15} 1 if regions from west and south only	-0.114*** (0.032)	-0.115*** (0.033)
D_{22} 1 if annual GRP growth as dependent	-7.916*** (0.082)	-0.204*** (0.036)
D_{24} 1 if initial stock is controlled for	0.112*** (0.032)	0.114*** (0.030)
Constant	0.079** (0.034)	0.066** (0.030)
Number of observations	75	69
Number of studies	7	6
R^2 (total)	0.997	0.708
R^2 (within)	0.175	0.196
R^2 (between)	0.999	0.951

Note: As for Table 7.8.

other regions, then the local effect on patent production will be smaller. This is according to expectations since if interregional R&D effects exist they probably will have a positive impact on local patent production and hence the local effects are exaggerated. Smaller local effects on patent production are also the case for the studies that control for initial patent stock or gross regional product (GRP) value in the region.

Moreover, on average, government R&D expenditure has a lower impact on patent production compared to the reference case, which is in line with the stylized facts in Section 3.2. Also, studies conducted on regions in the western or southern part of Europe demonstrate larger local effects from R&D efforts.

To control for possible publication bias we have introduced a dummy variable for whether a study is published or not. The hypothesis is that there is a preference for publishing statistically significant estimates of a

positive relationship between R&D expenditure and patent production. If this is true, a published study should on average have a higher β -value. However, the result in Table 7.8 shows the opposite; that is, a working paper reports, on average, larger local R&D effects.

The meta-regression results with the spillover effect as the dependent variable are presented in Table 7.9.¹² In order to check the robustness of the results two regressions are conducted – one with the full sample (i.e. with 7 studies) and one where the outlying observations from Crescenzi et al. (2007) were omitted. According to the table, the spatial weighting regime seems to matter. If R&D expenditures in other regions are weighted by distance in kilometers or minutes (instead of a binary contiguity matrix), then the spillover effect will on average be larger. Studies conducted on regions in the western or southern part of Europe demonstrate smaller spillover effects from R&D efforts (contrary to the local effects; see Table 7.8). If the initial patent stock or GRP value is controlled for, then the region demonstrates higher spillover effects, which is also contrary to the local effects seen in Table 7.8. The other estimates reported in Table 7.7 are similar to the ones found for the local effects.

5. CONCLUSIONS

In this chapter we focus on one type of externality, namely knowledge spillovers. The empirical studies of the effects of knowledge spillovers in Europe have normally focused on the localized effects on either total factor productivity or knowledge production measured in terms of patent output. The purpose of this chapter is to quantitatively review the empirical literature on spatial knowledge spillovers in Europe by means of meta-analysis to determine the extent to which such spillovers have been empirically documented, as well as their spatial reach. In addition, we apply meta-regression analysis to analyse the determinants of observed heterogeneity across and between publications. Our results show that if total local R&D expenditure in a European region increases by 1 per cent, then the number of patents in that region, on average, increases by 0.482 per cent. Government R&D expenditure is found to have a lower impact on patent production compared to private R&D expenditure. Also, studies conducted in regions in the western or southern part of Europe demonstrate larger local effects from R&D efforts. The spatial weighting regime seems to matter. If R&D expenditures in other regions are weighted by distance in kilometres or minutes (instead of a binary contiguity matrix), then the spillover effect will on average be larger.

NOTES

1. Acknowledgement(s): ESPON TIGER work package 2.3.3.
2. Griliches (1979) makes a distinction between pure knowledge spillovers and rent spillovers, where the latter arise because new goods and services are purchased at less than their fully quality-adjusted prices. Transaction-related knowledge flows here represent rent spillovers.
3. It is interesting to note that research on other types of linkages between universities and industry other than those related to patents and publications are rare, despite the fact that other channels for knowledge flows and knowledge spillovers, such as consulting, contract research and training programmes, are probably more frequently used in practice (D'Este and Patel, 2007; Link et al., 2007).
4. The model with the unmodelled effects is usually called the spatial error model. The model with both unmodelled and modelled effects is the so-called spatial lag model.
5. Inputs for spillover knowledge effects are weighted by distance.
6. See Section 3.2 for further details.
7. Further discussion on the procedure of extracting the data is covered in Section 3.
8. Since most publications run several regression models, the number of β coefficients per publication can exceed 1.
9. We have reviewed more than 100 publications in total and selected about 40 publications for further analysis. However, the majority of this selection has used irrelevant methods of interpreting the knowledge variable or a quantitative approach not suitable for our purpose, thus narrowing down our sample to 13 publications.
10. In the meta-regression model we will control for these β coefficients by using a dummy variable.
11. Also included in the cluster-specific random-effects model is a study random effect that controls for study-specific effects that are common to all individual estimates from the same study.
12. Only the GLS-RE results are presented since the results from the OLS estimation were almost identical.

REFERENCES

- Allen, T.J. (1977), *Managing the Flow of Technology*, Cambridge, MA: MIT Press.
- Anselin, L. (2003), 'Spatial externalities, spatial multipliers and spatial econometrics', *International Regional Science Review*, **26**(2), 153–66.
- Anselin, L., A. Varga and Z.J. Acs (1997), 'Entrepreneurship, geographic spillovers and university research: a spatial econometric approach', ERSC Centre for Business Research, University of Cambridge, Working Paper No. 59.
- Archibugi, D. and A. Coco (2004), 'International partnerships for knowledge in business and academia. A comparison between Europe and the USA', *Technovation*, **24**, 517–28.
- Archibugi, D. and B.-Å. Lundvall (eds) (2001), *The Globalizing Knowledge Economy*, Oxford: Oxford University Press.
- Arrow, K.J. (1962), 'Economic welfare and the allocation of resources for invention', in R.R. Nelson (ed.), *The Rate and Direction of Inventive Activity*, Princeton, NJ: Princeton University Press, pp. 609–26.
- Arrow, K.J. (1994), 'The production and distribution of knowledge', in G. Silverberg, and L. Soete (eds), *The Economics of Growth and Technical*

- Change: Technologies, Nations, Agents*, Aldershot, UK and Brookfield, VT, USA: Edward Elgar, pp. 9–19.
- Audretsch, D.B. and M. Feldman (1996), 'Knowledge spillovers and the geography of innovation and production', *American Economic Review*, **83**, 630–40.
- Audretsch, D.B. and M. Feldman (2004), 'Knowledge spillovers and the geography of innovation', in V. Henderson and J. Thisse (eds), *Handbook of Urban and Regional Economics*, Amsterdam: Elsevier, pp. 2713–39.
- Autant-Bernard, C., J. Mairesse and N. Massard (2007), 'Spatial knowledge diffusion through collaborative networks', *Papers in Regional Science*, **86**, 341–50.
- Autant-Bernard, C. and N. Massard (2007), 'Pecuniary and knowledge externalities as agglomeration forces: empirical evidence from individual French data', in J. Surinach, R. Moreno and E. Vayà (eds), *Knowledge Externalities, Innovation Clusters and Regional Development*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 111–35.
- Borts, G.H. and J.L. Stein (1964), *Economic Growth in a Free Market*, New York: Columbia University Press.
- Botazzi, L. and G. Peri. (2000), 'Innovation and spillovers: evidence from European regions', CESifo Working Papers, No. 340, CESifo, Munich, Germany.
- Botazzi, L. and G. Peri. (2003), 'Innovation and spillovers in regions: evidence from European patent data', *European Economic Review*, **47**, 687–710.
- Breschi, S. and F. Lissoni (2001), 'Localized knowledge spillovers vs. innovative milieux: knowledge "tacitness" reconsidered', *Papers in Regional Science*, **80**, 255–73.
- Breschi, S. and F. Lissoni (2009), 'Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows', *Journal of Economic Geography*, **9**, 439–68.
- Crescenzi, R. and A. Rodriguez-Pose (2008), 'Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe', *Regional Studies*, **42**(1), 51–67.
- Crescenzi, R., A. Rodriguez-Pose and M. Storper (2007), 'The territorial dynamics of innovation: a Europe–United States comparative analysis', Working Paper, London School of Economics, London.
- Crespi, G., A. Geuna and L. Nesta (2006), 'Labour mobility of academic inventors: career decisions and knowledge transfer', EUI Working Papers RSCAS No. 2006/06, European University Institute, Florence.
- D'Este, P. and P. Patel (2007), 'University–industry linkages in the UK: what are the factors underlying the variety of interactions with industry?', *Research Policy*, **36**, 1295–313.
- Disdier, A.-C. and K. Head, (2008), 'The puzzling persistence of the distance effect on bilateral trade', *Review of Economics and Statistics*, **90**(1), 37–48.
- Dixon, R. and A.P. Thirlwall (1975), 'A model of regional growth-rate differences on Kaldorian lines', *Oxford Economic Papers*, **27**, 201–14.
- Dohse, D. (2000), 'Technology policy and the regions – the case of the bioregion contest', *Research Policy*, **29**, 1111–133.
- Eaton, J. and S. Kortum (1996), 'Trade in ideas: productivity and patenting in the OECD', *Journal of International Economics*, **40**, 251–78.
- Ellison, G. and E. Glaeser (1997), 'Geographic concentration in US manufacturing industries: a dartboard approach', *Journal of Political Economy*, **105**, 889–927.

- Englmann, F.C. and U. Walz (1995), 'Industrial centers and regional growth in the presence of local inputs', *Journal of Regional Science*, **35**, 3–27.
- Feldman, M.P. (1999), 'The new economics of innovation, spillovers and agglomeration: a review of empirical studies', *The Economics of Innovation and New Technology*, **8**, 5–25.
- Greunz, L. (2003), 'Geographically and technologically mediated knowledge spillovers between European regions', *The Annals of Regional Science*, **37**(4), 657–80.
- Griliches, Z. (1979), 'Issues in assessing the contribution of research and development to productivity growth', *The Bell Journal of Economics*, **10**, 92–116.
- Griliches, Z. (1992), 'The search for R&D spillovers', *Scandinavian Journal of Economics*, **94**, 29–47.
- Griliches, Z. and F.R. Lichtenberg (1984), 'R&D and productivity growth at the industry level: is there still a relationship?', in Z. Griliches (ed.), *R&D, Patents and Productivity*, Chicago IL: University of Chicago Press, pp. 465–502.
- Hauser, C., G. Tappeiner and J. Walde (2008), 'Regional knowledge spillovers: fact or artefact?', *Research Policy*, **37**, 861–74.
- Head, K., J. Ries and D. Swenson (1995), 'Agglomeration benefits and location choice: evidence from Japanese manufacturing investment in the United States', *Journal of International Economics*, **38**, 223–47.
- Jaffe, A. (1989), 'Real effects of academic research', *The American Economic Review*, **79**, 957–70.
- Jaffe, A. and J. Lerner (1999), 'Privatizing R&D: patent policy and the commercialization of national laboratory technologies', NBER Working Paper No. 7064, National Bureau of Economic Research, Cambridge, MA.
- Jaffe, A. and M. Trajtenberg (1996), 'Flows of knowledge from universities and federal labs: modeling the flow of patent citations over time and across institutional and geographical boundaries', *Proceedings of the National Academy of Sciences*, **93**, 12671–677.
- Jaffe, A., M. Trajtenberg and M. Fogarty (2000), 'The meaning of patent citations: report of the NBER/Case Western Reserve survey of patentees', NBER Working Paper No. 7631, National Bureau of Economic Research, Cambridge, MA.
- Jaffe, A., M. Trajtenberg and R. Henderson (1993), 'Geographical localization of knowledge spillovers as evidenced by patent citations', *Quarterly Journal of Economics*, **108**, 577–98.
- Jeppesen, T., J.A. List and H. Folmer (2002), 'Environmental regulations and new plant location decisions: evidence from a meta-analysis', *Journal of Regional Science*, **42**, 19–49.
- Karlsson, C. and B. Johansson (2006), 'Dynamics and entrepreneurship in a knowledge-based economy', in C. Karlsson, B. Johansson and R.R. Stough (eds), *Entrepreneurship and Dynamics in the Knowledge Economy*, New York: Routledge, pp. 12–46.
- Karlsson, C. and A. Manduchi (2001), 'Knowledge spillovers in a spatial context – a critical review and assessment', in M.M. Fischer, and J. Fröhlich (eds), *Knowledge, Complexity and Innovation Systems*, Berlin: Springer, pp. 101–23.
- Keilbach, M. (1998), 'Marshallian externalities and the dynamics of agglomeration and regional growth', Working Paper No. 1998/19, Technical University, Berlin.
- Krammer, Sorin M.S. (2009), 'Drivers of national innovation in transition:

- evidence from a panel of Eastern European countries', *Research Policy*, **38**, 845–60.
- Krugman, P. (1991), *Geography and Trade*, Cambridge, MA: MIT Press.
- Krugman, P. (1998), 'Space; the final frontier', *Journal of Economic Perspectives*, **12**, 161–74.
- Link, A., D. Siegel and B. Bozeman (2007), 'An empirical analysis of the propensity of academics to engage in informal university technology transfer', *Industrial & Corporate Change*, **16**, 641–55.
- Lucas, R. (1993), 'Making a miracle', *Econometrica*, **61**, 251–72.
- Maggioni, M.A., M. Nosvelli and E. Uberti (2007), 'Space vs. networks in the geography of innovation: a European analysis', *Papers in Regional Science*, **86**(3), 471–93.
- Melo, P.C., J.D. Graham and R.N. Noland (2009), 'A meta-analysis of estimates of urban agglomeration economies', *Regional Science and Urban Economics*, **39**, 332–42.
- Miguélez, E. and R. Moreno (2010), 'Research networks and innovators mobility as drivers of innovation: evidence from Europe', Working Paper 2010/01, Research Institute of Applied Economics, University of Barcelona.
- Moreno, R., R. Paci and S. Usai (2003), 'Spatial spillovers and innovation activity in European regions', Crenos Working Papers, No. 2010:10, Cagliari, Italy.
- Moreno, R., R. Paci and S. Usai. (2005), 'Spatial spillovers and innovation activity in European regions', *Environment and Planning*, **37**, 1793–812.
- Myrdal, G. (1957), *Economic Theory and Underdeveloped Regions*, London: Duckworth.
- NSF (2002), *Science and Engineering Indicators*, National Science Foundation, US GPO, Washington, DC.
- Perroux, F. (1955), 'Note sur la notion de pôle de croissance', *Économie Appliquée*, **7**, 307–20.
- Pinto, H. (2010), 'Knowledge production in European Union: evidence from a national level panel data', MPRA Working Paper No. 27283, Algarve, Portugal.
- Pinto, H. and P.M.M. Rodrigues (2010), 'Knowledge production in European regions: the impact of regional strategies and regionalization on innovation', *European Planning Studies*, **18**(10), 1731–48.
- Ponds, R., F. van Oort and K. Frenken (2007), 'The geographical and institutional proximity of research collaboration', *Papers in Regional Science*, **86**, 423–43.
- Premer, M. and U. Walz (1994), 'Divergent regional development, factor mobility, and non-traded goods', *Regional Science and Urban Economics*, **24**, 707–22.
- Romer, P.M. (1986), 'Increasing returns and long-term growth', *Journal of Political Economy*, **94**, 1002–37.
- Romer, P.M. (1990), 'Endogenous technological change', *Journal of Political Economy*, **98**, S71–S102.
- Stanley, T.D. (2001), 'Wheat from chaff: meta-analysis as quantitative literature review', *Journal of Economic Perspectives*, **15**, 131–50.
- Stanley, T.D. and S.B. Jarrell (1989), 'Meta-regression analysis: a quantitative method of literature reviews', *Journal of Economic Surveys*, **3**, 161–70.
- Varga, A., D. Pontikakis and G. Chorafakis (2010), 'Agglomeration and inter-regional network effects on European R&D productivity', IAREG Working Paper, No. 5/22, University of Pecs, Hungary.
- Verspagen, B. (1994), 'Technology and growth: the complex dynamics of convergence and divergence', in G. Silverberg and L. Soete (eds), *The Economics of*

Growth and Technical Change: Technologies, Nations, Agents, Aldershot, UK and Brookfield, VT, USA: Edward Elgar.

Wallsten, S.J. (2001), 'An empirical test of geographical knowledge spillovers using GIS and firm-level data', *Regional Science and Urban Economics*, **31**, 571–99.

APPENDIX

Abbreviation of variables in Table 7.4:

AERI	accessibility to extra-regional innovation
AERI _{WEI}	weighted accessibility to extra-regional innovation
AIPEA	accessibility to innovation-prone extra-regional areas
GDP _{CAP}	gross domestic product per capita
HTP	high-technology patents
P	patents
P _{CAP}	patents per capita
PGY	patents granted per year
RD _{EMP}	R&D employment
RD _{EMP/W}	R&D employment per worker
RD _{EXP}	R&D expenditure
RD _{EXP/W}	R&D expenditure per worker
RD _{EXP/C}	R&D expenditure per capita
RD _{EXP%/GRP}	R&D expenditure as percentage of gross regional product
RD _{EXP%/GDP}	R&D expenditure as percentage of gross domestic product
RD _{EXPG%/GDP}	R&D expenditure as percentage of gross domestic product, public
RD _{EXPB%/GDP}	R&D expenditure as percentage of gross domestic product, private
RD _{EXPG}	R&D expenditure public
RD _{EXPB}	R&D expenditure business
RD _{SPE}	R&D spending
SWANR	spatially weighed average of neighbouring regions' R&D
TAIPS	total accessibility to innovation-prone space
YP _{APP}	yearly patent applications
YP _{APP/W}	yearly patent applications per worker
YP _{APP/C}	yearly patent applications per capita

8. Innovation, efficiency and economic integration

Aikaterini Kokkinou

1. AN INTRODUCTION TO PRODUCTIVE EFFICIENCY

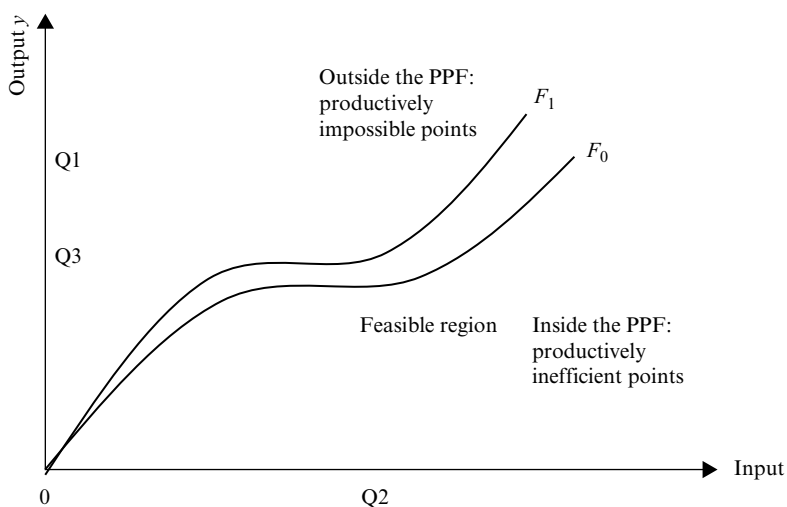
Nowadays, the economic role of innovation and efficiency enhancement in economic integration and convergence is even more important, taking into consideration the slowdown and the effects created by the current financial crisis. Within this framework, the key factors influencing the integration and convergence process are creation and diffusion of innovation, along with productive efficiency enhancement, mainly around three key areas: innovation and research, strengthening networks and clusters; and efficient use of production factors.

Within this framework, when one considers productivity comparisons, an additional source of productivity change, called technical change, is possible. This involves advances in technology that may be represented by an upward shift in the production frontier. This is represented in Figure 8.1 by the movement of the production frontier from $0F_0$ to $0F_1$ in period 1.

In period 1, all firms can technically produce more output for each level of input, relative to what was possible in period 0. When we observe that a producer has increased productivity from one period to the next, the improvement need not have been from efficiency improvements alone, but may have been due to technical change or the exploitation of scale economies, or from some combination of these three factors (Coelli et al., 2005).

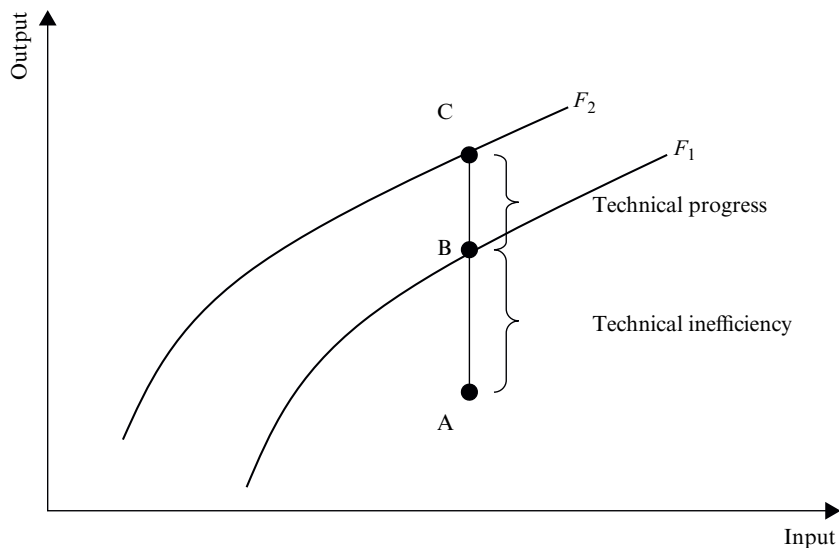
The optimum level of production is defined in terms of the production possibilities frontier (PPF). Technological change is assumed to push the frontier of potential production upward, while efficiency change will change the capability of productive units to improve production with available inputs and technology. Figure 8.2 illustrates this idea.

As illustrated in Figure 8.2, F_1 and F_2 are production frontiers in periods 1 and 2, respectively. Technical efficiency, which is represented by a movement towards the frontier from A to B, refers to the efficient



Source: Based on Coelli et al. (2005), p. 6.

Figure 8.1 Production frontiers and technical efficiency



Source: Mahadevan (2002), p. 7.

Figure 8.2 The frontier and non-frontier total factor productivity growth measure

use of inputs and technology due to the accumulation of knowledge in the learning-by-doing process, diffusion of new technology, improved managerial practices and so on. Thus AB shows technical inefficiency in period 1. The absence of technical inefficiency in the non-frontier approach is related to the implicit assumption of long-term equilibrium behavior whereby producers are said to be fully efficient as they have had time to learn and adjust their input and technology use appropriately. Thus the non-frontier total factor productivity (TFP) growth measure is only made up of the movement from B to C, which represents technical progress due to technological improvements incorporated in inputs. Hence technical progress and TFP growth are used synonymously when the non-frontier approach is used. Unlike the non-frontier approach, the frontier approach is able to decompose output growth not just into input growth and TFP growth; it goes a step further to decompose TFP growth into various efficiency components such as technical progress and gains in technical efficiency.

2. PRODUCTIVE EFFICIENCY DETERMINING FACTORS

In the modern knowledge economy, growth depends extensively on the presence or the formation of a network and environment favorable to innovation, which is based on endogenous development capabilities. Even though the producer-specific factors are important determinants of innovation activity technological opportunities and favorable entrepreneurial environment have a positive effect on innovation activity as well. Technological change, innovation and technology creation and diffusion are important factors in economic progress.

Combining the production functions in order to create and disseminate innovations leads to improvements in productivity and efficiency. However, at a given moment of time, when the technology and the production environment are essentially the same, producers may exhibit different productivity levels due to differences in their production efficiency. Within the growth process, therefore, the efficiency of production resources becomes a critical element in growth, through utilizing the available, yet scarce, resources more productively. Within this framework, productivity represents the estimation of how well a producer uses the available resources to produce outputs from inputs. However, the productivity theory literature has emphasized factors such as productive efficiency, mainly through technological spillovers, increasing returns, learning by doing, and unobserved inputs (e.g. human capital quality), whereas the

empirical industrial organization literature has emphasized the degree of openness of countries to imports and industry structure (Koop, 2001).

Consequently, one of the main tasks is to investigate the relationship between inefficiency and a number of factors which are likely to be determinants, and measure the extent to which they contribute to the presence of inefficiency. These factors are neither inputs to the production process nor outputs of it, but nonetheless exert an influence on producer performance. Such factors are widely referred to as efficiency explanatory variables.

Within this framework, based on Wang (2007), since R&D is one of the most crucial elements in promoting growth, it is argued that any production unit that uses R&D resources inefficiently may be subjected to a growth penalty in the form of a much smaller benefit from R&D investment. If R&D resources are not used effectively, additional investment may be of little help in stimulating economic growth. Literature has already been devoted to investigating the economic aspects and effects of R&D investment. It has been considered that R&D could result in better production technology and also raise the productivity as well as the rates of return on investment at both the producer and industry levels.

Technology and innovation play an important role in productive efficiency with a multiple role: as motive force they direct the producers to ambitious and long-term objectives, lead to the renewal of methods of production, supply and distribution, and management and marketing, as well as industrial structures and the appearance of new industries of economic activity, achieving a wider spectrum of products and services, as well as relative markets. Inputs affect the intermediate inputs, which consequently affect and define the productivity and competitiveness level. As mentioned earlier, technological change, innovation and technology creation and diffusion are an important factor in economic progress.

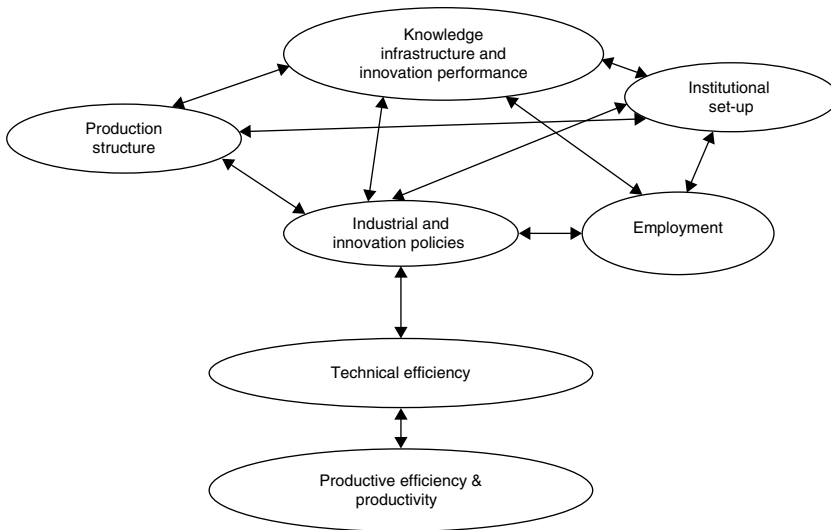
On the other hand, as broadly described in Galli  and Roux (2010), in the last two decades R&D cooperation has attracted a considerable amount of attention. Many empirical studies, in economics or in management, have investigated the motives for and potential benefits of cooperation as compared to internal R&D. Cooperation enables firms to internalize knowledge spillovers, facilitates knowledge transfers between them (in particular between firms and universities), helps them gain access to complementary knowledge and technologies, generates scale economies of research, enables firms to speed the commercialization of new products or technologies, to avoid duplicative R&D efforts, to share costs and risk and to gain access to foreign or new markets. After R&D collaboration, cooperation was most often captured as a homogeneous object (i.e. R&D cooperation versus internal R&D).

Following the main findings from the literature survey, there are two complementary sets of conditions that need to be satisfied for industries to sustain productivity and efficiency in a competitive environment. The first is that they must have suitable levels of both physical infrastructure and human capital. The second is that, in the new knowledge-based economy, they must have the capacity to innovate and to use both existing and new technologies effectively. Industrial and innovation policy is aimed at strengthening the competitiveness of producers by promoting competition, ensuring access to markets and establishing an environment which is conducive to R&D. As recognized, lack of innovative capacity stems not only from deficiencies in the research base and low levels of R&D expenditure, but also from weaknesses in the links between research centers and businesses, and slow take-up of information and communication technologies. Knowledge and access to it have become the driving force of productivity, much more than natural resources or the ability to exploit abundant low-cost labor have become the major determinants of economic competitiveness, since it is through these that industries can increase their productive efficiency. Innovation, therefore, holds the key to maintaining and strengthening efficiency, which in turn is essential for achieving sustained economic development.

These environmental factors are spatially confined externalities with different scales of influence. Some factors, such as the legal and cultural framework or large research institutes, operate mainly at national level, generating national systems of innovation (Lundvall, 1992). Other factors, such as skilled labor supply and networks linking firms and support institutions, have a more limited territorial span, and are the basis of regional systems of innovation (Braczyk et al., 1998).

3. PRODUCTIVE EFFICIENCY AND ECONOMIC INTEGRATION: THE CASE OF THE EUROPEAN UNION

As technical efficiency enhancement becomes an increasingly important issue, production must draw on a wide range of production ideas, component technologies and complementary capabilities. Within this framework, it is rather difficult for any single industry to incorporate and take advantage of the relevant technological advances, as well as the underlying industrial and innovation policies. This means that the actions of industries involve the targeted development of specialized knowledge assets, which are integrated from a wider range of knowledge areas (Kessler et al., 2000).



Source: Own elaboration.

Figure 8.3 *Productive efficiency and institutional framework*

European technology and innovation policies are no longer exclusively in the hands of national authorities: increasingly, national initiatives are supplemented by or even competing with regional innovation policies or transnational programs, in particular the activities of the EU.

At the same time, industrial innovation increasingly occurs within international networks. Research, technology and innovation policies of European countries clearly reflect the profiles of their national (and regional) 'innovation systems', understood as the various institutions, corporate actors and processes contributing to industrial and societal innovation. Figure 8.3 highlights the interactions among the main policy elements regarding the enhancement of technical and productive efficiency.

The spectrum of the implemented instruments of research, technology and innovation policy is widely differentiated in the meantime, reflecting the scope of institutions and interests involved: it stretches from public funding of research institutions over various forms of financial incentives to the conducting of research and experimental development in public or industrial research labs, up to the design of an innovation-oriented infrastructure, including the institutions and mechanisms of technology transfer. In many European countries, these instruments have dominated the practice or research and technology policy for the last three decades.

As further instruments one could mention efforts to guide public demand, measures in education and further training and the regulatory possibilities available. In the twenty-first century, though, national and (regional) innovation systems are experiencing revolutionary shock waves: the growing pull of internationalizing economic relationships has mixed traditional regional or national divisions of work between industrial enterprises, educational and research institutions as well as administration and politics, and it has debased many of their traditional strengths. Internationalization, however, has so far not led to a uniformity of the national innovation systems, which would finally mean their abolition. The various national and regional innovation cultures and related policy arenas react very differently, which partly leads them into crises, partly stabilizes, but partly also reveals unexpected, novel chances in a transformed international context. At the same time, European transnational innovation policies have been entering the stage, increasingly since 1985, and now cover the whole range of instruments (Kuhlmann, 2001).

4. PRODUCTIVE EFFICIENCY AND INNOVATION POLICY: THE CASE OF THE EUROPEAN UNION

Innovation policy seeks to help firms or industries to improve their capacity to innovate. This includes the provision of scientific infrastructure in research and education, and direct and indirect support for research and technological development. It also includes a wide range of policies which aim to build networks, to make markets more conducive to innovation, to facilitate the transfer of technology, to help firms to acquire relevant capabilities, and to provide a supporting infrastructure in areas such as standards and intellectual property. Public innovation policy aims to strengthen the competitiveness of an economy or of selected industries, in order to increase societal welfare through economic success (Kuhlmann, 2001). Hence the EU has made innovation a top priority through several strategies, funding opportunities and assessments. The pressures of globalization have brought innovation to the fore as a key element in increasing productivity along with technical efficiency and underpinning industrial competitiveness, taking into consideration the underinvestment in business R&D and other innovative activities, strongly linked to the fragmented condition of European markets.

Innovation policy is essential for EU productive efficiency and an important driver in enabling the EU to enhance competitiveness, increase efficiency and growth and consequently to compete on a global scale. However, policy makers have also underlined the need for interaction

between innovation policy and other policy areas to improve the environment for innovative enterprises (Chesbrough, 2002; Nilsson, 2004; Georghiou, 2006).

On the other hand, Europe's national innovation systems differ substantially, as do their innovation performances. Therefore member states have undertaken great efforts to improve their innovation support measures by investing in research and implementing new or better instruments in support of innovation. This level of financial engagement is at risk in the current global economic crisis and, as a direct impact, the innovation gap in the EU is widening again. The implication of this is that innovation policy must consider the needs of a wide set of industries – policy initiatives need not be confined to a small group of highly innovative sectors. The EU is challenged in the global arena by emerging economies when it comes to capturing and capitalizing on knowledge and technology in the context of innovation. In the past few years, the budget for R&D has been increased and several initiatives have been launched to strengthen Europe's competitiveness. So far, however, these efforts have not made the EU more competitive.

The majority of public initiatives are still mainly developed in national policies offered by national institutions. While in recent years member states increasingly tended to compete with each other in the field of innovation policy, strong industrial or financial capital actors have been appearing more frequently on the scene – multinational enterprises, international strategic alliances of national enterprises – who act globally and across the national innovation systems. In the member states of the EU this policy initially took the form of initiatives for stimulating research, improving innovation financing and promoting technology absorption and innovation management.

Additional priorities such as intensifying the cooperation between research, industry and universities, promoting 'clustering' and other forms of cooperation among enterprises and other organizations involved in the innovation process, and encouraging the start-up of technology-based companies were added to the national innovation policy (Nilsson, 2004).

As part of the Europe 2020 strategy, in 2010 the Commission launched an ambitious new industrial policy that highlighted the actions needed to strengthen the attractiveness of Europe as a place for investment and production, including the commitment to monitor member states' competitiveness policies. The changing nature and scope of global innovation activities creates very significant consequences for EU innovation policy, requiring a substantial review of the pillars of EU innovation policy, involving both the scope and the governance of innovation at the EU and national level (Anvret et al. 2010).

The EU has identified the following key areas where the competitiveness of the EU economy could be further strengthened in order to make significant progress towards the Europe 2020 goals (European Commission, 2011):

- facilitating structural changes in the economy, in order to move towards more innovative and knowledge-based sectors that have a higher productivity growth and have suffered less from global competition;
- enabling innovation in industries, in particular by pooling scarce resources, by reducing the fragmentation of innovation support systems and by increasing the market focus of research projects;
- promoting sustainability and resource efficiency, in particular by promoting innovation and the use of cleaner technologies, by ensuring fair and undistorted pricing of energy and by upgrading and interconnecting energy distribution networks;
- improving the business environment, in particular by reducing the administrative burden on businesses and by promoting competition among service providers that use broadband, energy and transport infrastructure;
- benefiting from the single market, by supporting innovative services and by fully implementing the Single Market Regulation, in particular the Services Directive;
- supporting small and medium-sized enterprises (SMEs), in particular by favouring access to finance, by facilitating internationalization and access to markets.

EU industry must accelerate its efforts to adopt these technologies to keep its competitive edge in the world, with research and innovation driving productivity growth and industrial competitiveness. A transition towards a sustainable, resource-efficient economy is paramount for maintaining the long-term competitiveness of European industries. Overall, European member states have made significant progress in defining and implementing consistent national legislative frameworks for stimulating efficiency. However, some lack the experience and the administrative capacity to do this and for these countries the framework legislation at the EU level can provide guidance and support.

The quality and availability of infrastructure (energy, transport and broadband) make an important contribution to an efficiency-promoting environment. Industrial sectors need a modern public administration, able to deliver efficient and high-quality public services (European Commission, 2011). Coordinating clusters and networks improve industrial

competitiveness and innovation by bringing together resources and expertise, and promoting cooperation among businesses, public authorities and universities. EU industrial and innovation policies should aim to overcome existing market failures and funding gaps, especially to supply the bridge between technical efficiency and productivity enhancement.

5. POLICY IMPLICATIONS AND CONCLUDING REMARKS

Nowadays, the role of manufacturing industries in the economy is even more important, taking into consideration the slowdown in the world economy and the effects on the business environment created by the financial crisis. Thus manufacturing industries have a very important role in creating opportunities, making an important contribution to economic growth and development. However, due to their nature, manufacturing industries are characterized by great heterogeneity since they differ in their endowments of resources as well as on the risks involved in their productive activities. For this reason, it is of great importance, on the one hand, to analyze their efficiency level and potential, and, in addition, to analyze the factors that determine their efficiency potential.

The key factors influencing the competitiveness of the EU manufacturing industry are access to innovation, R&D and international trade. The main recommendations revolve around three key areas: innovation and research, and strengthening networks and clusters; responsible use of natural resources; and the need for open world markets with fair competition. Clustering, collaboration and the formation of strategic alliances are becoming increasingly important. Continuous R&D and innovation efforts are essential elements in guaranteeing the long-term competitiveness of Europe's manufacturing industries. European research, technical development and innovation policies should focus on developing the framework conditions that stimulate innovation, entrepreneurship and, thus, growth and employment. Innovation for sustainable manufacturing requires paying attention to the interfaces of R&D policies with other critical policy fields. Strong emphasis needs to be placed upon the management of the interfaces of R&D policy and other policy realms – competition policy, intellectual property rights, standardization, education and training, environmental policy, the labor market, employment and social policy – to facilitate the creation of a sustainable European manufacturing industry environment, along with fiscal instruments and incentives. Understanding future challenges and issues is important in future developments in manufacturing. Industrial change driven by new technological

opportunities will impact on the manufacturing structures in the EU contributing to sustainable growth and improving technical efficiency.

The potential for technical efficiency enhancement is considered to a large extent to depend on the EU's capability to transform the economy into one that makes more productive use of its resources. Much will depend on the capacity of markets to facilitate the reallocation of resources to industries that show rapid productivity growth. However, it is difficult to predict which industries will be the most productive in the future, as technology and innovation trends are inherently difficult to forecast. For now, a productive use of a larger input from skilled employment and the exploitation of information and communication (ICT) investments in manufacturing industries appear the most successful policy avenues for a European productivity revival.

Promoting technical and productive efficiency in the EU has resulted in a growing challenge for policy makers. Productive and regional disparities and inequalities are an increasing issue for the EU to resolve; as a result, policy makers have to adapt the policy agenda considering industrial and innovation policy in order to enhance technical and productive efficiency capabilities.

Moreover, efficiency and policy planning is a major matter which, due to its wide interpretations and implications, should have a clear mix of principles and priorities, mainly focusing on the effectiveness of the related EU policies. EU industrial and innovation policy should aim to bridge the technical efficiency gaps, both at industrial and country level, benefiting economic cohesion, allowing member states with a backwards economy or backwards industries to modernize and thus compete in European and international markets, promoting convergence, competitiveness and cooperation. Infrastructure, innovation and investments should be among the main goals.

European governments are in need of a more coherent, more coordinated approach towards industrial technical efficiency support. However, the pressure on public budgets adds to the urgency of this matter in different policy areas of industrial and innovation policy. The range of explicit innovation policies being applied is very much concerned with the supply side and even more with R&D support of various types, ranging from funding of science in public institutions through to fiscal incentives for firms to increase R&D spend. A comprehensive approach to industrial and innovation policy can be achieved by supporting markets for innovative goods and services, and excellence in research in new technologies, including ICT, introducing a more focused strategy to facilitate the creation of areas for action, and in particular introducing a more focused strategy to facilitate the creation and marketing of new innovative products

and services. Within the domain of industrial and innovation policy, regulatory reform is seen to affect innovation indirectly by affecting the funds available for investment and market size and structure, and directly through its impact on the promotion of technical efficiency and productivity (Lengrand, 2003).

An open, efficient and competitive business environment is a crucial catalyst for growth in a global context. Improving the business environment covers policies in areas ranging from improving infrastructure to shortening the time needed to obtain a building license. In many cases, better institutional mechanisms need to be functioning as a single research area, business environment and innovation system. There need to be strategic approaches that promote closer interaction not only among sectors but also among policy makers (from different policy fields and different levels of government). European innovation and industrial policy is therefore recommended to develop strategic approaches that integrate R&D, innovation and industrial policy along with a more coherent EU strategy for innovative competitiveness, giving special attention to ICT in innovation and industrial policy (ETEPS, 2011).

At the national level, governments could set up agencies funded by public bonds with the mission to provide venture capital, investment credits and R&D support to new activities in the above fields. Productive efficiency and competitiveness would be strengthened by:

- pooling scarce resources to help to achieve critical mass in bringing innovation to the market; and by increasing cooperation in innovation to create large-scale demonstration projects and pilot test facilities;
- reducing the fragmentation of innovation support systems, facilitating bringing innovative solutions to the market, and increasing the market focus of research projects;
- developing support for innovative services based on measurable outcomes;
- facilitating the growth of manufacturing industries by ensuring that regulations do not pose obstacles to expansion; by favoring access to appropriate finance; and by providing support services for accessing new markets, and publicizing these.

A new generation of policies must overcome the limitations and failures of past experiences, such as collusive practices between political and economic power, heavy bureaucracy, lack of accountability and entrepreneurship. They have to be creative and selective, with decision-making mechanisms that are more democratic and inclusive of different social

interests. These new approaches to industrial and innovation policies could play a key role in pulling Europe out of the current crisis. The politics behind such a new departure must be based on a wide social consensus over the distribution of the productivity and efficiency gains deriving from new technologies and economic activities (Pianta, 2010).

Industrial and innovation policy programs and projects claim to contribute to technical efficiency. This implies that policies should concentrate on areas in which there is expansion and therefore good prospects for growth. Community businesses should become more competitive, and scientific and technological progress is expected to offer a medium- or long-term potential for dissemination and exploitation (Kuhlmann, 2001). An open, efficient and competitive business environment is a crucial catalyst for growth in a global context. Rising to these challenges can improve the competitiveness of European manufacturing industries, and the Commission aims to help the member states to use their limited resources efficiently in order to increase the global competitiveness of their industries. Addressing these challenges will improve the growth prospects of industries. A competitive industry can lower costs and prices, create new products and improve quality, thus contributing decisively to wealth creation and productivity growth throughout the economy.

The difficult fiscal environment sets limits to policy action, but robust growth will reduce the burden of public deficit and debt, in line with the goals of the Stability and Growth Pact. For this an environment that favors new ideas and new businesses is required. Innovation is the primary driver of a successful and sustainable industrial policy. A strong lead in R&D and innovation is Europe's key competitive advantage and of central importance in finding solutions to economic challenges (European Commission, 2011). With increased globalization, one can only hope that industry will be an engine for the spreading of social progress, environmentally friendly technologies and innovations worldwide (Soete, 2007). To achieve a truly sustainable, positive effect for manufacturing industry and the workforce it employs, the EU and its member states should aim to avoid the relocation of manufacturing activities and related services (e.g. R&D, ICT) and support the permanent upgrading of European manufacturing industries.

REFERENCES

- Anvret, M., Granieri, M. and Renda, A. (2010), 'A new approach to innovation policy in the European Union. Innovation Policy: Boosting EU Competitiveness in a Global Economy, CEPS Task Force Report, 8 July.

- Braczyk, H.J., Cooke, P. and Heidenreich, M. (1998), *Regional Innovation Systems*, London: UCL Press.
- Chesbrough, H. (2002), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston, MA: Harvard Business School Press.
- Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and Battese, G.E. (2005), *An Introduction to Efficiency and Productivity Analysis*, 2nd edn, New York: Springer.
- ETEPS (2011), Innovation and Industrial Policy, IP/A/ITRE/ST/2010-06, Brussels: European Parliament.
- European Commission (2011), *Industrial Policy: Reinforcing Competitiveness*, COM(2011) 642 final, Brussels.
- Gallié, E.-P. and Roux, P. (2010), 'Forms and determinants of R&D collaborations: evidence based on French data', *Industry & Innovation*, **17**(6), 551–76.
- Georgiou, L. (2006), 'Effective innovation policies for Europe – the missing demand side', PREST, Manchester Business School, University of Manchester.
- Kessler, E., Bierly, P. and Gopalakrishnan, S. (2000), 'Internal vs. external learning in new product development: effects on speed, costs, and competitive advantage', *R&D Management*, **30**(3), 213–23.
- Koop, G. (2001), 'Cross-industrial patterns of efficiency and technical change in manufacturing', *International Economic Review*, **42**(1), 73–103.
- Kuhlmann, S. (2001), 'Future governance of innovation policy in Europe – three scenarios', *Research Policy*, **30**, 953–76.
- Lengrand, L. (2003), 'Innovation tomorrow – innovation policy and the regulatory framework: making innovation an integral part of the broader structural agenda', Directorate General for Enterprise Innovation Papers No.28, EUR 17052.
- Lundvall, B.-Å. (ed.) (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.
- Mahadevan, R. (2002), 'New currents in productivity analysis: where to now?', Productivity Series 31, Asian Productivity Organization, APO, Tokyo.
- Nilsson, J.E. (2004), *Innovation Policy as an Alternative to Institutional Changes*, Bollschweil: Hagbarth Publications.
- Pianta, M. (2010), 'After the crisis: towards a sustainable growth model', available at http://works.bepress.com/mario_pianta/69.
- Soete, L. (2007), 'From industrial to innovation policy', *Journal of Industry, Competition and Trade*, **7**, 273–84.
- Wang, E.C. (2007), 'R&D efficiency and economic performance: a cross-country analysis using the stochastic frontier approach', *Journal of Policy Modeling*, **29**(2), 345–60.

Index

- Acharya, V.V. 78
Acs, Z.J. 170
adoption 17, 42, 43, 50, 52, 55, 57, 60, 101
Aliber, R.Z. 60, 61, 80
Amendola, G. 43, 56
Anderson, B. 100
Anselin, L. 145, 153, 170
Antonelli, C. 43, 57
Anvret, M. 183, 188
Arrow, K.J. 146, 150
Ashcraft, A. 81
Asheim, B.T. 89, 90, 97
Audretsch, D.B. 145, 151, 152, 171
Autant-Bernard, C. 57, 151, 152, 171
- Bachtler, J. 107, 113, 117
Bierly, P. 189
Boesky, H. 81, 189
Bordo, M.D. 69, 79
Borts, G.H. 146, 171
Braczyk, H.J. 180, 189
Brandenburger, A.M. 28, 30, 35
Breschi, S. 87, 97, 148, 150, 171
British Business Angels Association 59
Brueckner, J.K. 71, 79
- Calem, P.S. 79
Campbell, D. 4, 5, 7, 10, 11, 13, 14, 15, 19, 20, 21, 24, 28, 35, 36, 37, 40, 41, 124, 127, 135
Carayannis, E.G. 3, 5, 17, 20, 26, 29, 33, 123, 124, 127, 128, 134
CDO (collateralized debt obligation) 63, 64, 66, 67, 68, 69, 71, 72, 73, 77, 78, 79
CDS (credit default swaps) 66, 67, 68, 69, 71, 72, 78, 80
CEC (Commission of the European Communities) 89, 97
Chen, E. 46, 57
CLOE (Clusters Linked Over Europe) 110, 117
clusters 5, 7, 11, 14, 21, 22, 29, 37, 113, 118, 124, 141, 171, 176, 184, 185
Coelli, T.J. 176, 177, 189
Cooke, P. 89, 97, 107, 110, 117, 189
Collier, S.J. 101, 117
Cumbers, A. 104, 117
- Date, R. 68, 79
Davies, S. 47, 57
DeLanda, M. 100, 101, 102, 117
demand side 42, 45, 189
Deutsche Bundesbank 76
DG-Industry 108, 109
DG-Regio 108, 109
diffusion 3, 4, 5, 6, 11, 15, 18, 27, 28, 29, 35, 36, 37, 38, 42, 43, 44, 45, 46, 47, 48, 49, 51, 56, 86, 88, 90, 91, 96, 103
Dixon, R. 146, 171
Dodd–Frank Act 60, 76, 77
Dohse, D. 145, 171
Doloreux, D. 89, 97
Dosi, G. 86, 97, 135
- economic integration 176, 180, 181
ecosystem 3, 5, 9, 11, 14, 15, 29, 31, 34, 37, 39, 124, 126, 127, 131, 132, 134, 137, 140
efficiency 94, 95, 176, 178, 179, 180, 181, 184, 185, 187, 188
Ellison, G. 145, 171
Englmann, F.C. 145, 172
epidemic model 46, 47
ERDF 109, 118
ESPON TIGER work package 170
Etzkowitz, H. 8, 14, 24, 38
Europe 2020 58, 59, 60, 74, 79, 115, 142, 183, 184

- European Commission 58, 59, 60, 76, 79, 92, 94, 97, 98, 109, 117, 118, 119, 184, 188, 189
- Exchange Commission (SEC) 61, 64
- Fannie Mae 62, 63, 72, 73, 77, 79, 81
- FDI (foreign direct investment) 45, 80, 129, 130
- Fed 61, 62, 63, 72, 73, 77, 78, 80, 81
- Federal Deposit Insurance Corporation (FDIC) 61, 68, 78
- Federal Housing Administration (FHA) 61, 77
- Federal Reserve System's Fourth Annual Community Affairs Research Conference 63, 77
- Feldman, M.P. 40, 118, 145, 151, 152, 171
- Foray, D. 113, 118
- Fuest, C. 76, 79
- Gallié, E.-P. 179, 189
- Geanokoplos, J. 61, 80
- geographical knowledge spillovers 145, 174
- Gertler, M. 90, 97, 105, 118
- Gerybadze, A. 29, 38
- Ginnie Mae 62, 63
- Glaeser, E. 145, 171
- Glass-Steagall Act 61
- Godoe, H. 32, 38
- Google Scholar 144, 145
- Gopalakrishnan, S. 189
- Gorodetsky, O. 69, 78
- Granieri, M. 188
- Greenspan, A. 63, 77
- Griliches, Z. 42, 57, 144, 146, 148, 152, 170, 172
- Hall, R. 35, 39, 61, 81
- Harrison, P. 100, 117
- hedge funds 63, 69, 73
- Hemmelgarn, T. 79
- Henderson, R. 172
- Henderson, V. 171
- Housing and Urban Development (HUD) 62, 77
- Huang, R. 69, 73, 80, 81
- ICT (information and communication technology) 35, 45, 111, 130, 135, 154, 186, 187, 188
- innovation paradox 111, 118
- inter-industry innovation approach 44
- Interreg 112
- intra-regional knowledge spillovers 145
- IRE (Innovating Regions in Europe) 118
- Jaffe, A. 144, 145, 152, 153, 172
- Jarrell, S.B. 147, 173
- Jessop, B. 109, 116, 118
- JPMorgan 66, 72, 80
- Karlsson, C. 144, 148, 149, 152, 172
- Keilbach, M. 145, 172
- Kessler, E. 180, 189
- Kindleberger, C.P. 60, 61, 76, 80
- knowledge creation 3, 4, 5, 11, 15, 23, 28, 29, 31, 35, 36, 37, 40, 91, 109, 124, 135, 155, 156
- knowledge production function (KPF) 152, 154, 155, 156, 157, 162
- knowledge spillovers 144, 145, 146, 147, 148, 149, 150, 151, 152, 154, 155, 157, 159, 163, 169, 171, 172, 174, 179
- Kokkinou, A. 176
- Konczal, M. 68, 79
- Kondratieff cycle 44, 46
- Koop, G. 179, 189
- Korres, G.M. 42, 43, 44, 46, 57, 85, 86, 87, 89, 90, 94, 98
- Krugman, P. 145, 146, 173
- Legendijk, A. 99, 103, 104, 109, 118
- Latour, B. 102, 103, 118
- Lehman Brothers 72, 73, 81
- Lehman study 69
- Leydesdorff, L. 8, 24, 38
- Lindblom, C.E. 32, 35, 39
- Lipsey, R.E. 74, 75, 80
- Lisbon Strategy 112
- Lissoni, F. 148, 150, 171
- logistic curve 46, 48
- Lucas, R. 146, 173
- Lundvall, B.-Å. 20, 22, 39, 86, 97, 98, 151, 170, 180, 189

- Madigan, P. 66, 78, 80
 Manca, F. 57
 Mansfield, E. 44, 50, 57
 Massard, N. 57, 152, 171
 Massey, D. 111, 118
 McFadden Act 61
 McFarlane, C. 100, 118
 Merrill Lynch 72, 73
 meta-analysis 151, 152, 157, 158, 159, 160, 169, 172, 173
 MNCs (multinational companies or corporations) 16
 Moreno, R. 57, 152, 155, 156, 161, 162, 163, 171, 173
 Morgan, K. 110
 Morgan Stanley 72, 78
 mortgage-backed securities (MBS) 62, 63, 66, 73, 77
 Myrdal, G. 146, 173
- Nakamura, A.O. 58, 60, 79, 80
 Nakamura, L.I. 58, 79, 80
 Nakamura, M. 58, 79, 80
 National Systems of Innovation (NSIs) 38, 39, 86, 87, 88, 90, 91, 97
 Nationally Recognized Statistical Rating Organizations (NRSRO) 64, 65, 66, 74, 77
 'new economic geography' 146, 150, 172
 NUTS-1/NUTS-2 areas 109, 145, 158, 159, 160, 166
- OECD (Organisation for Economic Co-operation and Development) 9, 12, 13, 23, 40, 73, 77, 104, 171
 Office of Financial Research 60
 Ong, A. 101
 Oughton, C. 111, 118
- Polanyi, M. 86, 98
 Porter, M.E. 110, 118
 Pozsar, Z. 68, 81
 Premier, M. 145, 173
 Prince, R. 100, 101, 103, 104, 105, 118
 probit analysis 49
 process innovation 50, 51, 52, 55, 57, 58, 86
 product innovation 50, 51, 52, 55, 63, 76, 86
 productive efficiency 176, 178, 179, 180, 182, 186, 187
- quadruple helix 9, 10, 11, 25, 30, 31, 32, 33, 37, 127, 134, 135, 137, 139
 quality and quantity 4
- Ramb, F. 79
 Ratnovski, L. 69, 73, 80, 81
 Redish, A. 79
 Regional Innovation and Technology Transfer Strategies (RITTS) 108, 109, 110, 113, 117
 Regional Systems of Innovation (RSIs) 83, 85, 88, 90, 91
 Renda, A. 188
 Rockoff, H. 79
 Romer, P.M. 146, 173
 Roux, P. 179
- S-shaped epidemic diffusion curve 47, 56
 Sahal, D. 50, 57
 Schumpeter, J.A. 16, 31, 38, 40, 43, 44, 46, 57, 97
 Sipp, C. 29, 38
 smart specialization 99, 112, 113, 114, 115, 116
 Soete, L. 112, 113, 114, 119, 171, 177, 183, 189
 spatial 6, 21, 22, 87, 97, 99, 102, 106, 108, 109, 112, 113, 114, 116, 144, 145, 147, 151, 152, 153, 154, 157, 158, 159, 164, 165, 167, 169, 170, 180
 spatial knowledge spillovers 144, 145, 147, 148, 152, 169
 special investment vehicle (SIV) 64, 73
 spillovers 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 155, 156, 163, 167, 169, 170
 Standard & Poor's (S&P) 65
 Stanley, T.D. 72, 78, 147, 173
 Stein, J.L. 146, 171
 Steinmueller, W.E. 25, 40, 171
 Stoneman, P. 43, 46, 57
 supply side 42, 44, 45, 55, 106, 108

- Suriñach, J. 45, 50, 51, 52, 53, 57
 Swenson, D. 172
 SWOT scripts 109
 systems of innovation 11, 22, 23, 38,
 39, 40, 83, 85, 87, 88, 90, 91, 97
 technical efficiency 176, 177, 178, 180,
 181, 182, 185, 186, 187
 technological change 42, 43, 44, 46, 57,
 118, 176, 178, 179
 technology creation and diffusion 178,
 179
 TFP (total factor productivity) 178,
 179
 Thirlwall, A.P. 146, 171
 Tornazky, L.G. 16, 40
 Trajtenberg, M. 152, 172
 UNIDO 133
 Uranga, M.G. 97
 Varga, A. 39, 156, 161, 162, 163, 170,
 173
 Varró, K. 99, 105, 112, 119
 Von Hippel, E. 24, 32, 40
 von Zedtwitz, M. 3, 5, 22, 29, 38, 41
 Wallsten, S.J. 145, 174
 Walz, U. 145, 172, 173
 Wang, E.C. 179, 189
 Warda, P. 144
 Woodward, S. 61, 81
 Zaltman, G. 17, 41
 Ziemnowicz, C. 32, 38